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The recovery of function during physiotherapy: A theoretical basis for stroke rehabilitation.

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THE RECOVERY OF FUNCTION DURING PHYSIOTHERAPY : A
THEORETICAL BASIS FOR STROKE REHABILITATION

Susan Jane Mawson

A thesis submitted in partial fulfilment of the requirements for the award
of Doctor of Philosophy awarded by Sheffield Hallam University

17th September 1997

Collaborating Organisation.. The Northern General Hospital,
NHS Trust

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The final Validation process involved the collaboration of ten National Stroke Units and 20 senior physiotherapists, their support and enthusiasm enabled me to produce a catalogue of TELER indicators that is now being used extensively.

This study, was an attempt at establishing the outcome of Physiotherapy for stroke patients and I owe a great debt to the patients who, during their routine physiotherapy assessments and treatments, provided the information that became the TELER indicators, without these patients there would have been no study.

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Abstract

This research was undertaken to address a number of problems identified in the literature, the most fundamental issue being, the lack of evidence of effective physiotherapy intervention for stroke patients. It appeared that a contributing factor was a lack of appropriate measuring tools that fulfilled both the theories of measurements and the theoretical basis of current physiotherapy practice.

The purpose of the study was therefore, to choose a measure, define and validate the measure and to use the measure to develop knowledge and understanding of not only the outcome of physiotherapy, but also the physiotherapy process itself. The Bobath Approach was chosen for evaluation as this appeared, from the literature, to be the least evaluated and the most frequently used approach in the UK.

A triangulation of qualitative and quantitative methodology was used in a research programme that was divided into four phases:

- 1. Identifying the measurement needs in stroke rehabilitation and choosing a measure that fulfilled the required specification.*
- 2. Having chosen the TELER method, developing TELER Indicators definitions in a patient driven study, involving the clinical knowledge of practising physiotherapists and 'expert' physiotherapists in the area of neurological rehabilitation.*
- 3. Validating the definitions of the TELER Indicators using the Motor Assessment Scale.*
- 4. Using the developed measure in 4 single case studies.*

The research involved 71 stroke patients on 12 stroke units, scored on a total of 322 functional goals, 247 demonstrating a consolidation and acquisition pattern, The study established the characteristics of functional recovery during physiotherapy, providing information and knowledge regarding the model of intervention used, and the pattern of selective trunk muscle recovery occurring. It was concluded that, motor relearning does occur during the implementation of the Bobath Approach for the treatment of stroke patients and furthermore, it was established that, there is a misunderstanding of the concept of spontaneous recovery within the literature. The similarities and differences between the Bobath Approach and the Motor Relearning Programme were identified, establishing a theoretical basis for stroke rehabilitation.

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ABBREVIATIONS

ACPIN	Association of Physiotherapists with a Special Interest in Neurology
ADL	Activities of daily living
BBA	British Bobath Association
BBTA	British Bobath Tutors Association
B o S	Base of support
C o G	Centre of gravity
CI	Cerebral infarction
C o M	Centre of mass
CNS	Central nervous system
CPG	Central pattern generator
CSP	The Chartered Society of Physiotherapists
CT	Computed Tomography
CVA	Cerebral vascular accident.
DoH	Department of Health
EMG	Electromyography
FIM	Functional Independence Measure
FMA	Fugl-Meyer Assessment
ICIDH	International Classification of Impairment Disability and Handicap
IDH	Impairment disability and handicap
LBD	Left brain damaged
LTP	Long Term Potentiation
MAS	Motor Assessment Scale
MRI	Magnetic Resonance Imaging

MRP	Motor Relearning Programme
NHS	National Health Service
NIH	National Institute of Health Stroke Scale
NINDS	National institute of Neurological Disorders of Stroke
OHE	Office of Health Economics
OPCS	Office of Population Census and Surveys
OPFI	Ordinary physical function indicators
PNF	Proprioceptive neuromuscular facilitation
Post PT	(scores observed) following physiotherapy
Post WE	(scores observed) following a period of no physiotherapy (weekend)
RBD	Right sided brain damage
RCT	Randomised controlled trials
SPFI	Standard Physical Function TELER Indicators
STD	Stand
TELER	Treatment Evaluation by Le Roux's Method
WHO	World Health Organisation

CHEMICAL SYMBOLS.

Ca	Calcium
Mg	Magnesium
Na	Sodium
K	Potassium

INTRODUCTION

'Life as we know it would not be possible without the capability to move, without movement we would not survive, without measurement the physiotherapy profession will not survive.'

Adapted from Schmidt (1988)

THE PROBLEM

Stroke is known to be the third leading cause of death in the United Kingdom, however the true 'Burden of Stroke' for the rehabilitation team rests not in the morbidity statistics of epidemiology studies, but in the levels of impairment, disability and handicap occurring as a result of a stroke. Stroke survivors, with cognitive and motor deficits, receive expensive and time-consuming rehabilitation programmes, the purpose of which is to induce recovery within the Central Nervous System and reduce functional disability.

In a recent document produced by the Department of Health (1990), the Government highlighted the need to develop effective measures of outcomes attributable to health care interventions. The document specifically identified the Rehabilitation services for evaluation and, in particular, the costly implementation of stroke rehabilitation.

Moves within the National Health Service to a competitive market place philosophy with purchaser-provider contracts dictating the allocation of resources have inevitably resulted in an urgent need, by physiotherapists, to quantify the outcomes of intervention strategies. As a profession physiotherapists have become increasingly aware of the need to promote evidence based practice, however historically the evidence regarding effective intervention within the literature is limited and inconclusive.

The reasons for this lack of evidence and resultant lack of consensus on the most appropriate approaches within the field of stroke rehabilitation, are two fold. Firstly, the research designs used are inappropriate for the multifarious nature of the disease, and the resultant deficits produced. Secondly, and more importantly, the measurement tools used to identify effective practice frequently lack a sound theoretical basis and therefore lack validity as measures of physiotherapy outcome.

A further problem for stroke physiotherapists in the United Kingdom lies in the lack of published evidence of the theoretical basis of physiotherapy approaches and, in particular, the Bobath Approach (Bobath, 1990) taught at undergraduate and postgraduate level throughout the UK. The literature would suggest that this concept and associated treatment techniques, developed in the 50s and 60s, has failed to integrate scientific developments in the fields of motor control and behavioural science within treatment strategies. In contrast protagonists of the Motor Learning Approach (Carr and Shepherd, 1987a,b) developed in Australia in the 70s and 80s, appear to have responded to new knowledge by moving towards a cognitive, biomechanical model of intervention. Antagonisms and conflicts have developed between advocates of the two treatment methods which may have inhibited the growth of stroke rehabilitation as a physiotherapy speciality.

Whilst much has been published regarding the scientific evidence of how the central nervous system (CNS) can respond to internal and external environmental information, there is little if any evidence of this concept underlying the therapeutic processes implemented following damage to the CNS during a stroke. Neuroplasticity, together with an understanding of the implications of stroke pathology, and neuroanatomy, have significant implications for the treatment methods used, whether they be the Bobath Approach or the Australian Motor Relearning Programme.

In order to evaluate the outcome of physiotherapy for stroke patients, information is urgently required regarding not only the physiotherapy process implemented in the UK, but also of the neurophysiological, behavioural and biomechanical mechanisms involved in that process. How stroke patients recover the ability to move normally again, and whether this recovery is attributable to physiotherapy intervention, are crucial questions in the present health service environment where evidence based practice has become an essential prerequisite for survival. To be able to provide this information a measuring system is required that fulfils, not only the theories of measurement, but also the theoretical basis of the approach being evaluated.

THE RESEARCH APPROACH

The study was divided into four distinct phases, each fulfilling specific objectives, in a combination of qualitative and quantitative methodologies.

Phase I

- Initially, the identification of the criteria to be fulfilled by a measuring system, and the subsequent choice of the TELER method was achieved by using a qualitative approach.

Phase II

- The second phase, involved the development and validation of the TELER Normal Movement Indicators in a patient-driven project utilising clinical and 'expert' knowledge, in a Delphi and consensus meeting technique that culminated in the final measure. During the developmental process, evidence was provided about the model of intervention used by the Bobath physiotherapists, and about the recovery of motor function during physiotherapy.

Phase III

- The final set of TELER indicators were then validated against the Motor Assessment Scale (Carr and Shepherd et al., 1985) in the third phase of the study.

Phase IV

- During the fourth phase, the TELER Indicators were used in a single case study approach involving four stroke patients.

THE CONCLUSIONS

During this study to establish a theoretical basis for stroke rehabilitation, it became apparent that physiotherapists using the Bobath Approach, 'Bobath trained physiotherapists', were using a model of physiotherapy that focused on the rehabilitation of selective trunk and limb girdle activity, as a basis for the restoration of normal postural alignment and balanced movement. This selective muscle activity became the item of interest during the recovery process, as they appeared to be the fundamental mechanisms by which patients relearn to move normally.

Evidence indicated, that the recovery of function following a stroke involved a hierarchical, parallel process of selective trunk and limb girdle activity relearned by

repetition of automatic and volitional activities. The recovery occurred in a consolidation and acquisition pattern superimposed upon which repeated 'fallbacks' were recorded. Logical conclusions suggesting that these represented the short and long term cellular mechanisms underlying motor learning.

It became apparent that Bobath physiotherapists were re-educating the selective trunk activity through the sub-cortical motor control systems of the cerebellum and the spinal cord by using automatic responses to internal and external environment cues. This explanation of their treatment strategy is in conflict with the cortically controlled, volitional, highly specialised limb muscle reeducation of the Motor Relearning approach. In the light of the discussion regarding the pathology of stroke and the functional anatomy of the central nervous system, it was concluded that the approach utilised by the Bobath physiotherapists was more effective in the rehabilitation of early stroke patients. However, further research is needed to confirm this.

Furthermore, evidence was provided that the concept of 'spontaneous recovery' was inappropriately being used in the medical literature. A pattern of recovery was observed during the study that would suggest, recovery processes induced by the initial neural damage, only attributed to recovery occurring within the first few weeks following a stroke.

The findings demonstrated, not only that withdrawing physiotherapy resulted in an interruption in motor skill relearning, but also that the Bobath Approach utilises neurophysiological, behavioural and biomechanical principles to guide and promote neural recovery following a stroke.

Having chosen the TELER system as fulfilling the criteria for a measure of physiotherapy outcome, the development of the TELER indicators, and their subsequent use in a single case approach, resulted in new knowledge about the recovery of function during physiotherapy and the identification of a theoretical basis for stroke rehabilitation.

SECTION 1

A PROBLEM BASED REVIEW OF THE LITERATURE:

The purpose of this review is to identify in the literature, not only the problems to be addressed by this study, but also their origins and to establish their importance in the context of the proposed research in Physiotherapy for stroke patients.

CHAPTER 1

1. THE BURDEN OF STROKE

1.1 Epidemiology

'A large proportion of stroke victims are left with permanent disability, and the human and economic consequences of stroke extend far beyond what emerges from routine mortality data.'

WHO MONICA Stroke Study Asplund et al., (1995)

Epidemiology is the study of the distribution and causes of disease in a given population and has always been an integral part of medical practice (Barker et al., 1990). Numerous studies have established both the frequency and changing distribution patterns of diseases to enable the allocation of medical resources. Although medical research has traditionally examined disease rates and mortality rates, current interest in health expectancy, whether extra years of life are spent in good or poor health, changes the focus towards quality of life for survivors of stroke and outcomes from care in terms of ability to function. Therefore, in this study of stroke rehabilitation, what is perhaps more important than incidence and mortality rates is the prevalence of stroke induced disability.

The review will therefore present some information on stroke mortality rates together with evidence of the longer term effects of stroke in terms of residual functional ability. In doing this, it will be possible to identify the resource implications of this burden of care for physiotherapists working with stroke survivors and their carers.

Unfortunately, in population based epidemiological studies, there are often methodological difficulties and data provided may be unreliable (Asplund et al., 1995). In a review of stroke incidence studies Malmgren et al., (1987) concluded that few studies provided accurate information.

There are numerous reasons for these problems. In a report published by the Scottish Health Services Advisory Council (1993) it was suggested that none of the many studies carried out in the UK over the past 30 years have continued long enough to provide conclusive evidence of a changing incidence pattern. It was also suggested that the exclusion of certain groups, such as non-hospitalised patients, resulted in potential underestimation of incidence levels.

The ability to make an accurate pathological diagnosis has also influenced the reliability of incidence data. In a paper published in the Lancet by Rowe et al., (1988) the authors cite the previous lack of computer tomography techniques as a factor in the underestimation of the incidence of primary intercerebral haemorrhage.

In 1982, Parry complained that despite the International Classification of disease (WHO, ICIDH, 1980), interpretation of epidemiological studies was complicated by the lack of a common definition of '*stroke*'. Since then, the WHO (1988) has defined stroke as:

'rapidly developing clinical signs of focal or global disturbance of cerebral function, with symptoms lasting 24 hours or longer or leading to death, with no apparent cause other than vascular origin.'

As a working definition, it is precise enough to distinguish stroke from other cerebrovascular diseases, such as transient ischaemic attacks, yet general enough to cover haemorrhagic and ischaemic cerebrovascular accidents. However, as Bonita (1992) suggests, far from improving the accuracy of prevalence estimations, it is responsible for reducing accuracy. By specifying '*no apparent cause other than vascular origin*' the definition excludes '*transient ischaemic attacks, subdural haematoma, and haemorrhage or infarction caused by infection or tumour.*' Consequently, epidemiological studies are likely to underestimate the total burden of people with hemiplegia or stroke resulting from other pathologies. Such methodological problems in

the study of stroke epidemiology have inevitably resulted in an underestimation of and lack of consensus on the total burden of stroke to society,

The largest epidemiological study of stroke carried out in the UK over the past decade was the Oxford Community Stroke Project (Bamford et al., 1988). This was a prospective study of the incidence and outcome of first ever stroke in a population of 103,000 people registered with 10 general practices in Oxfordshire. Data provided by this study covered the period between November 1981 and October 1984 and (CT) scans were used to establish the pathological type of stroke involved.

TABLE 1

Age-Sex Specific Annual Incidence Rates per 1,000 Population for First-Ever Stroke

	<u>Males</u>	<u>Females</u>	<u>Total</u>
< 45 years	0.08	0.11	0.09
45 - 54 years	0.67	0.46	0.57
55 - 64 years	3.47	2.35	2.91
65 - 74 years	8.11	5.84	6.90
75 - 84 years	15.87	13.39	14.34
> 85 years	18.42	20.36	19.87

Source: Oxfordshire Community Stroke Project (from the Management of Patients with Stroke 1993, Scottish Health Service Advisory Council)

In the study, a total of 515 patients with a first ever stroke were identified, with an incidence rate of 2 per 1,000 population when adjusted to the 1981 population of England and Wales. Table 1 lists the annual incidence rates of first ever strokes per 1,000 population showing a step rise with age for both sexes.

In order to predict the burden of stroke on the health care systems, Malmgren et al., (1989) used data provided by the Oxford stroke project to estimate the potential number of first ever strokes that will occur in England and Wales every five years until 2023.

(See Table 2.) For the year 1996 Malmgren estimated a total population of first ever stroke as 109,537.

TABLE 2

Projected Number of First Ever Strokes in England and Wales: 1983-2023 (men and women)

<u>Age (Yrs)</u>	<u>1983</u>	<u>1986</u>	<u>1991</u>	<u>1996</u>	<u>2001</u>	<u>2006</u>	<u>2011</u>	<u>2016</u>	<u>2021</u>	<u>2023</u>
< 45	2,599	2,611	2,620	2,603	2,608	2,570	2,488	2,440	2,459	2,482
45-54	2,863	2,826	3,027	3,459	3,510	3,480	3,881	3,964	3,467	3,229
55-64	17,432	16,809	15,779	15,515	16,669	19,075	19,327	19,249	21,508	21,972
65-74	32,014	32,268	32,232	31,666	29,948	29,672	32,152	37,024	37,524	36,603
75-84	36,017	37,866	38,985	38,325	39,085	38,612	37,164	37,536	41,565	45,738
> 85	11,634	13,055	15,715	17,969	19,308	20,262	21,663	22,151	22,517	23,105
Total No	102,559	105,435	108,358	109,537	111,128	113,671	116,675	122,364	129,040	133,129

Adapted from Malmgren R et al., 1989

However, to more clearly identify the significance of this problem to the physiotherapy profession, further information must be reviewed to establish the survival rate for this population and the levels of disability that survivors may experience.

Taking Malmgren's predications of first ever strokes, it would be interesting to establish how many of these patients are likely to survive, by comparing these figures with known mortality data. The most up to date information on death rates from stroke has been published by the Department of Health (DoH) in their series on the Health of the Nation (1994).

In this stroke epidemiological overview the total mortality for all ages published for the year 1992 was 62,126. Taking Malmgren's predictions for 1991 as being reasonably accurate for 1992 as being 108,358, this would indicate a survival rate of 46,232 first ever stroke patients.

Recent studies have shown that there has been an overall fall in mortality rates (Moden, 1992; DoH, 1994). Data published in Stroke (DoH, 1993) using OPCS sources suggest a fall as high as 50% in the under 65 age group. However, this optimistic view is not supported by data published by Broderick et al., (1988), who suggest a slowing down in the decline of stroke incidence. Indeed Terent (1988), in a study of Swedish women, suggested an increase in the incidence rate of first ever stroke.

Whilst evidence regarding mortality trends for stroke remains unclear, it is clear that a large proportion of survivors will continue to exist and it is these patients and their carers for whom the burden of care will fall upon the multidisciplinary rehabilitation team.

1.1.1. The Residual Levels of Disability of Stroke Survivors

To establish the extent of the problem for the rehabilitation team, evidence regarding the level of disability remaining and the natural history of stroke must be reviewed. Dombovy et al., (1986) suggest, however, that attempting to estimate the residual disability of stroke survivors is problematic because of the methods of data collection and the validity of the measure used.

In the Framingham study, a large scale longitudinal study of residual disabilities limiting function for long term stroke survivors (Gresham et al., 1975, 1979), functional levels were recorded on 148 stroke patients and compared to the scores obtained from a control group of matched subjects. Nine types of functional disabilities were measured using the Donaldson ADL Evaluation form (Donaldson et al., 1973) and a questionnaire covering aspects of function and socialisation within and outside the home.

Mobility, however, was scored as independent regardless of the mechanisms used, ambulation with '*assistive devise*' being categories as independent mobility. Whilst patients may walk using a stick, calliper, rollator or electrical stimulator these assistive devices are used as compensatory strategies in the absence of normal motor control and it must be assumed that the patients still had a significant level of disability.

The statistical significance of the differences between the two groups was determined by the chi square method. Gresham found that a higher percentage of patients with stroke

experienced severe disability in each of the compared areas, however, the exact nature of the disability is difficult to establish, as patients' using assistive devices were included in the fully independent group (126 85%). From a physiotherapist's perspective, the results of the Framingham study in terms of identifying the residual motor deficits following a stroke may be an underestimation, with a potential lack of correlation between independence and full recovery.

Wade and Langton Hewer (1987), cite four community based studies, including the Framingham study, all suggesting that 60 - 75% of survivors are totally independent following stroke with 3 - 9% being totally dependent. However, the results of their own study of 976 acutestroke patients in the community demonstrated that only 45% were independent at 6 months.

One reason for this lack of consensus regarding the residual levels of disability following a stroke, may be related to the measures used. Wade and his co-author, scored patients on the Barthel Index to establish functional independence at 3 weeks and 6 months post stroke. One of the objectives of this study was to assess the reliability of the Barthel Index by comparing total scores with those obtained using the Motricity Index (Demeurisse et al., 1980). Wade and Langton Hewer comment that a high Barthel score implies functional independence, however, this does not in the authors' words '*imply normality*'. A patient may be independent but still have a significant level of impairment.

Whilst the Barthel Index scores, like the Donaldson ADL Evaluation, may be acceptable as an assessment of disability, the validity of both as a measure of normal recovery, the resolution of the impairment, is questionable. It might be assumed by Wade's statement that the patient achieved the goals scored by the Barthel Index but that the lack of normality may have been the result of compensatory abnormal strategies developed by the patient.

1.1.2. Measuring Disability: Compensation or Recovery.

Held (1993), in her chapter on the recovery of function after CNS damage, suggests that the compensation mechanisms used by stroke patients may limit the process of normal recovery. This concept of using compensatory mechanisms to achieve a motor goal has

been clearly identified by Le Vere (1988) in his review of recovery following brain damage. Citing his own experimental work (Le Vere and Davies, 1977; Le Vere et al., 1979), he suggests the dangers of compensation as they are a potential limiting factor to normal recovery, damaged areas of the brain failing to be challenged to recover.

The concept of recovery versus compensation will be discussed further in the light of the findings of this study. Here it serves to highlight potential underestimation of the problems facing the stroke rehabilitation team. Wade and Langton Hewers' results(1987), presented in Table 3, suggest that at 3 weeks approximately 50% of the patients were not independent in four functional items. At 6 months the highest level of independence was 85% in walking with dressing being 69% and stairs 65%. However, without a valid measure of normal recovery that does not include the use of compensatory strategies, the extent of the problem facing the physiotherapist, in terms of residual disability requiring intervention, is unclear.

It is difficult to establish in Wade and Langton Hewer's study, whether these patients were receiving any therapeutic input, an important variable when attempting to determine the frequency of disability after stroke. Information on functional levels was taken from 'the best available source for example, nurses, relatives, the patient' however the reliability of this data collection method is not discussed.

TABLE 3
Functional Independence After Stroke

	Time Post-Stroke	
	3 Weeks n = 626	6 Months n = 544
Transfer	333 (58%)	403 (81%)
Walking	346 (60%)	417 (85%)
Dressing	280 (49%)	340 (69%)
Stairs	268 (47%)	323 (65%)

It can be seen from these figures, which as previously identified may be an underestimate, that a significant number of the 46,232 stroke survivors, discussed earlier, will not be independent in a number of important functional areas by 6 months post stroke.

It is these patients with their residual disability that form the potential burden of care for physiotherapist. Recent Office of Health Economics Study (OHE, 1988) showed that cerebral vascular disease cost the National Health Service £550,000,000 in 1985, 3.9% of the total NHS budget.

The incidence of stroke has fallen over the past decade, preventative measures and health education has resulted in a reduction in the overall burden of stroke. However, the problem of long term survival following a stroke remains, as do the residual deficits experienced by stroke survivors. These disabilities will continue to produce a burden on both human and economic resources (WHO MONICA Stroke Study Asplund, 1995).

Evidence in the literature would suggest that individualised programmes of stroke rehabilitation (Ottenbacher and Jannell, 1993) and focused rehabilitation of stroke patients (Fergenson et al., 1979; Strand et al., 1985; Smith, 1982), do improve ADL skills, walking and transfer activities. The implication being that hospital and community based rehabilitation teams will play a crucial role in reducing the ultimate cost to the Health Service. The importance, however, of appropriate research design and measurement validity and reliability in measuring the ultimate level of functional recovery following a stroke, has also been identified in this review.

1.2 Pathology

'The Stroke of God's hand.'

Bamford, (1991 a)

It is thought that the word stroke comes from this original medical use of the word at a time when knowledge of the underlying causes of disease were totally unknown, when affliction was beyond earthly comprehension (Bamford, 1991a).

With the advent of modern technology and the development of medical science, our understanding of causative factors and the pathophysiology of stroke has moved forward from this early concept of divine intervention. However, a problem still exists for the

clinician in the ability to classify the pathological characteristics underlying a diagnosis of stroke.

'While it is easy for both laymen and doctors to reach a general diagnosis of stroke it is often impossible to characterise the pathology underlying the stroke with the degree of precision necessary to develop strategies for prevention, treatment and rehabilitation.'

Royal College of Physicians Report (1989)

Initially, the International Classification of stroke appears to be quite simple: *'a sudden neurological deficit of presumed vascular origin'*, however, it is the nature of the vascular origin and the subsequent clinical presentation that require further identification.

Once conditions that simulate stroke have been eliminated, a CVA can be divided into two pathological categories, cerebral infarction, a cerebral artery becoming blocked preventing oxygen and nutrient getting to the brain, and cerebral haemorrhage where there is a leakage of blood within or around the brain (Royal College of Physicians, 1989; Scottish Health Service Advisory Council, 1993).

Although the incidence of these categories can vary internationally, data provided by the Oxford Community Stroke project (Bamford et al., 1986) indicate that approximately 85% of strokes are the result of a cerebral infarction and 15% either intracerebral or subarachnoid haemorrhage. (Bamford et al., 1986).

As the literature suggests (Bamford et al., 1986), that the largest category of stroke patients are those who have had a cerebral infarction (CI) this category will be further classified into anatomical site of infarction. Sterman (1987) suggests, that a lack of identification or relevant subgroups may have, hindered the development and testing of new therapeutic processes. Bamford (1991a) further suggests that knowledge of pathophysiological mechanisms may enable more accurate prognosis for survival and functional recovery.

As physiotherapists are primarily involved in resolving impairments in order to improve functional ability, accurate identification of subgroups and prediction of outcome are an important issues. Physiotherapists need to have knowledge of potential recovery processes in order to prioritise treatment input, select appropriate treatment models and provide evidence of effective interventions. Physiotherapists also require this knowledge to enable the identification and validation of theoretical models that may form the basis of their clinical practise.

A report by the National Institute of Neurological Disorders and Stroke (NINDS, 1990) identifies three methods of subclassifying the largest category, cerebral infarction and is included in table 4.

TABLE 4

Anatomical Classification of Cerebral Infarction (NINDS)

Site of occlusion
• Internal carotid artery
• Middle cerebral artery
• Anterior cerebral artery
• Vertebral artery
• Basilar artery
• Posterior cerebral artery

However, as Bamford states this anatomical classification has one main drawback, being based on the site of the infarction. It would require invasive vascular studies to obtain information to classify all strokes and for the rehabilitation team, in some clinical settings, this would not be feasible. Of more value to the practitioner, would be a classification system that associated the site of the infarction, with the signs or neurological impairments resulting from the cerebral infarction.

A system used in a number of epidemiological studies (Bamford, 1991 b) and based on the clinical findings at the time of maximal deficit from the stroke is presented in Table 5.

TABLE 5

Subdivision of Subtypes of Cerebral Infarction according to site and clinical presentation.

- Total anterior circulation infarction
*motor and sensory deficit, ipsilateral haemianopia
and new disturbance of higher cerebral function*

- Partial anterior circulatory infarction
*any two of the above
or isolated disturbance of higher cerebral function*

- Posterior circulatory infarction
*unequivocal signs of brainstem disturbance
or isolated haemianopia*

- Lacunar infarction
*pure motor stroke
or pure sensory stroke
or pure sensory motor stroke
or ataxic hemiparesis*

Adapted from Bamford (1991b)

Whilst this method of subclassification incorporating clinical signs improves the clinicians' ability to manage the rehabilitation process, it is of limited use to physiotherapists. Physiotherapists require a means of identifying and recording the signs of the stroke, such as motor and sensory deficit, rather than the level or extent of the pathology. Of greater importance to the physiotherapist, is how these signs relate to the patients' symptoms and how these in turn affect the patients' ability to function.

The problem for physiotherapists, who need to assess and measure how stroke pathology affects individual stroke patients, is deciding on an inclusive framework for classification. Wade (1992b) states that, this is a particular problem in stroke rehabilitation because the

nervous system has many functions and therefore damage to that system can result in a large number of deficits, which may or may not respond to physiotherapy interventions.

This problem was partially alleviated by the World Health Organisation's model for the classification of diseases (WHO, ICDH, 1980). Badley (1993) states, that the purpose of this concept in classification was to enable a better understanding of the consequences of disease. The concept attempting to describe a disease, such as stroke, in terms of the impact on body mechanisms, the person themselves, and the person as a social being (Badley, 1993). These three aspects of the disease are defined as being the impairment, the disability and the handicap.

Badley suggests, that this theoretical framework enables the clinician to determine the interrelationship between impairment, disability and handicap and to develop indicators of need or outcome. To evaluate physiotherapy intervention in stroke rehabilitation, what is required is not a pathological diagnosis, but indicators of the impact of the stroke on the individual in order to determine how the intervention has altered the consequences of the disease.

The problem for physiotherapist in stroke rehabilitation are therefore two fold. Firstly, the nature of the disease and the system which it affects result in a variety of pathological categories each with their own clinical presentations or levels of impairment. Secondly, to evaluate the effects of intervention, a measurement is required of the impact of the stroke at the levels of impairment, disability and handicap.

Wade (1992c) suggests, that the problem is further complicated by the need to be clinically relevant to the individual, to their abilities and their level of independence. This question of measurement in stroke rehabilitation will be developed further in the literature review on health care measurement and the needs of the physiotherapy profession.

1.3 Organisation of Stroke Services

Dennis (1992) defines a stroke service as being:

'an organisation that delivers effective intervention to stroke patients and carers.'

Dennis (1992)

Although the management of stroke patients has changed in recent years with the establishment of specialist stroke rehabilitation teams, few health districts have a stroke policy or service (Dennis, 1992; Kings Fund Consensus Conference, 1988). A model of stroke services in which acute stroke patients are cared for on specialist units, involving multidisciplinary teams, would appear to be the exception rather than the rule. In a report written by the Scottish Health Service Advisory Council (1993) it is stated that only one stroke unit exists in Scotland and it would appear that there were only fifteen in the UK by the end of the 80's (Royal College of Physicians, 1989).

Bamford et al.,(1986) suggests, that up to 45% of patients in the UK are not admitted to any form of inpatient care and are managed in the community. In Wade and Langton Hewer's study (1987), presented earlier, 26% of 976 patients were never admitted to hospital for their stroke care. Carstairs (1976) found that 56% of stroke patients discharged into the community had been managed on general medical wards and 28% from geriatric beds. Langton Hewer (1990), in his article on rehabilitation after stroke, quotes the Office of Health Economics data suggesting that 42% of stroke patients are managed on medical wards.

Langton Hewer suggests, that there has been considerable criticism of the quality of care offered to stroke patients citing the Kings Fund Consensus Conference on Stroke (1988), he lists the main criticisms in his article. Whilst the Kings Fund Consensus Conference on Stroke was not an evaluation of services it serves to highlight the deficiencies in stroke service provision within the UK. The literature would therefore suggest, that few patients actually receive the same level of care, the implication being that stroke unit care is more preferable to medical wards or community care.

This lack of consistency in the implementation of stroke services has major implications for the evaluation, and development of multidisciplinary rehabilitation. As suggested by the Kings Fund, the service becomes fragmented, there is a breakdown in communications between the disciplines and '*delegation of care to inadequately trained staff.*' (Kings Fund Consensus, 1988). Whilst Dennis was primarily discussing medical management when he suggested that without a structured stroke service evaluation of clinical practice becomes impossible, this inevitably applies to other members of the rehabilitation team.

1.3.1. The Effectiveness of Stroke Units

How effective are stroke units and what are the outcome indicator used to assess the effectiveness of this model of stroke management? A number of studies outline the benefits of stroke units. Kalra (1994) cites four randomised controlled trials proclaiming the benefits of stroke units (Stevens et al., 1984; Garraway et al., 1980; Indredavik et al., 1991; Kaira et al., 1993), but the majority of the evidence concerns the reduction of short and long term morbidity rates.

Similarly, Langhome (1993) reports that a formal review of the evidence from a series of randomised trials reported between 1962 and 1993 has demonstrated that organised stroke care significantly reduces early death by more than 33%. In this study ten trials were identified, eight using appropriate randomisation procedures, with a total population of 1586 stroke patients allocated to either stroke units or general medical wards. The results showed conclusively that mortality was reduced both at three months and at a twelve month follow-up.

A randomised controlled trial on the benefits of stroke units undertaken by Indredavik et al.,(1991) looked not only at short term morbidity, but of more importance to physiotherapists, the location of the patient following discharge, and the functional status of the patients at six weeks and fifty-two weeks post stroke. The measure of functional status used was the Barthel Index (Mahoney, 1965). Whilst the evidence is quite clear regarding improved morbidity rates and home discharge for 25 patients randomised to

stroke units at both 6 weeks and 52 weeks, the evidence regarding improvements in functional status is less clear.

The authors report that the mean score on the Barthel Index at 6 weeks was 79.7 for 77 patients treated on the stroke unit and 65.8 for 71 patients treated on the medical wards ($p= 0.0014$). At 52 weeks stroke unit patients had a mean score of 84.7 and medical ward patients a mean score of 72.4 ($p=0.001$). Whilst these mean scores may have some value in providing a global picture of the patients level of disability, they do not provide useful information about the level of independence of individual patients. Indeed the earlier presentation regarding the use of this measure to evaluate the levels of disability experienced by stroke survivors would suggest that it failed to measure the functional recovery of patients.

Murdock (1992) supports this argument suggesting that the a '*ceiling effect*' may result in a patient with a maximum score of 100 not having achieved normal recovery. Similarly, the authors of the Index themselves identified that a patient may be independent in an institution but that the patient may not be able to live in the community (Mahoney and Barthel, 1965). At the other end of the scale, Eakin (1989) identifies a '*floor effect*' in that a patient scoring 0 may be either alert but bedbound or they could be unconscious (Murdock, 1992). This lack of sensitivity or responsivity to change might suggest, again, that the measure is unsuitable for use in any study attempting to establish the functional recovery of patients treated on a stroke unit as opposed to those treated on a medical ward.

Furthermore, whilst use of the mean Barthel scores enables researchers to use the more powerful parametric statistical tests, this method of analysis fails to determine which aspects of a rehabilitation package are in fact producing changes in the patients functional status. Indredavik, highlights this problem when trying to analyse the information provided in his study, as do both Strand et al., (1985) and Garraway et al., (1980).

Table 6, lists the studies presented and demonstrates the frequent use of the Barthel Index. Whilst the evidence of these studies would suggest an overall benefit to patients from stroke unit management, they do not prove any evidence of the contribution to this

TABLE 6 Stroke Unit Rehabilitation Efficacy Review

Adapted from Ernst (1990)
Pollock et al., (1993)

Reference	Core Location	Research Design	No	Mean Age Years	Duration of Study	Measure used	Outcome
Garraway et al., 1980	Stroke Unit	RCT	155	72.5	55 days	Barthel Index	60 days post stroke 50% of stroke patients & 32% of medical ward patients were independent. Difference lost at 1 year follow-up.
	Medical Ward		182	75 days			
Smith et al., 1981	Intensive Stroke Care	RCT	133	63	6/12	ADL Scores	ADL improvement greatest in intensive care group. Deterioration in self care group.
	Conventional Care		66	6/12			
	Staff Care		65				
Strand et al., 1985	Stroke Unit	Comparison no randomisation	110	72	21 days	ADL discharge location and length of stay	15% of stroke unit patients and 39% of medical ward patients remained hospitalised 3/12 post stroke.
	Medical Ward		183	73	31 days		
Stevens et al., 1978/79	Stroke Unit	RCT	112	n/a	mean 117 days	Discharge location length of stay	At one year stroke unit patients had improved survival and proportion returning to the community.
	Medical Ward		116	n/a	mean 113 days		
Indredavik, 1987	Stroke Unit	RCT	110	72.2	42 days	Barthel Index discharge location and length of stay	Functional status significantly better in stroke unit patients also greater population returned to community.
	General Medical Ward		110	73.7			

Reference	Core Location	Research Design	No	Mean Age Years	Duration of Study	Measure used	Outcome
Wood-Dauphinee et al, 1984	Traditional care	RCT	130	75	5 weeks	Barthel Index	Survival the same. Motor skills in males better in team care group. Functional abilities males better in team care group. Females no difference in either groups.
	Team care		n/a	74	5 weeks	Brunnstrom evaluation form	
Sivenius et al, 1985	Conventional care	Comparison groups	40			ADL Index	Better function in the intensive rehabilitation group.
	Intensive rehabilitation		45			Ambulation Index	
Feirgenon, 1979	Stroke Unit	Comparison groups	584	67.14	46.28 days	ADL, length of stay, walking ability	Stroke more like to be discharged and walk independently.
	Medical Ward		78	69.03	43.66 days		
Kalra et al., 1993	Stroke Rehab	RCT	245	77.8	Mean 52.3 days	Mortality, location of discharge, Barthel Index	Functional outcome better. Length of stay was shortened for certain patient groups only.
	General Medical Ward			78.6	123-2 days		
Edwards JA, 1990	Stroke Unit	Comparison groups	13	66.76	One month	ADL scale	Independence in ADL not significantly different.
	Non Stroke Unit		33	70.24			

apparent improvement in functional skills by individual members of the multidisciplinary team.

It can also be seen from this table that all but two studies (Strand et al., 1985; Sivenius et al., 1985) used randomised control trials to establish whether stroke units were more effective than other forms of stroke management. However, there are limitations to the use of this research design in rehabilitation studies. Andrews (1991), identified the value of the RCT in medical research, which '*involves a single organ, biochemical response or drug effect*' suggesting, however, that the RCT may be inappropriate in rehabilitation research where the objectives of the rehabilitation process is multifaceted. The control groups used in such studies, to establish the innate effect of the intervention, may have eliminated the components of clinical practice that produce the effect.

Similarly Altman and Bland (1995) suggest, that frequently the RCT does not show a significant difference between treatment groups and that this '*negative result*' often implies, wrongly, that there is no difference. They continue by explaining that this simply means there is no evidence of effect, a totally different statement that may reflect the nature of the study or the measurement system used rather than the value or effectiveness of the intervention.

The evidence presented would appear quite conclusive although Ernst (1990), in his review of stroke rehabilitation research, does cite three randomised trials where the usefulness of stroke units was less conclusive. (Feldman, et al., 1962; Gordon and Kohn, 1966; Peacock et al., 1972). Matyas and Ottenbacher (1993) suggest that this lack of consensus on the effectiveness of stroke rehabilitation relates to the problems of clinical trials in research design. This view is supported by Gresham (1990), who states that this problem may be partly due to the '*unacceptable amount of methodological heterogeneity*'. In a clinical situation it is this variability that requires recording and not controlling out, or excluding from any data collecting exercise.

Lind (1982), reviewing the results of stroke rehabilitation studies, examined the studies according to both design and analysis, concluding that the '*results of these studies conflict and the conclusions vary widely.*' This lack of agreement is also identified by the Royal College of Physicians in their published report on Stroke Management (1989).

Although a number of the studies reported by Langhorne (1993), that identified the benefits of stroke unit management (Garraway et al., 1980; Stevens et al., 1984; Strand et al., 1985; Wood-Dauphinee et al., 1984), were published before the Royal College report was written, they were ignored with the statement:

'there is no proof that stroke wards or rehabilitation wards alter the outcome in terms of morbidity or mortality.....'

Royal College of Physicians (1989)

'There have been several attempts to evaluate the use of stroke rehabilitation wards, for example in four recent randomised studies. There is a suggestion from at least one study that benefits do occur in those patients managed on stroke rehabilitation units.'

Royal College of Physicians (1989)

It would appear that the Royal College of Physicians feel that the evidence is not conclusive and further state that:

'stroke units for the acute phase as a standard model of care cannot be recommended generally.'

Royal College of Physicians (1989)

Whether it is this lack of support given by a key organisation in medical care within the NHS, or a lack of adequate information on the specific components and types of intervention that are effective in acute stroke rehabilitation, the problem for physiotherapists is immense. The neurological physiotherapist has to be able to demonstrate effective intervention strategies in order to maintain or increase resource allocation by providing evidence of long term reductions in the cost implications of stroke management.

To be able to establish the best ways to implement stroke services in the acute setting, the rehabilitation team and in particular the physiotherapy profession, must be more clear about the characteristics of acute stroke management, using both appropriate research

design and valid and reliable measurement tools that can record the recovery of function during the intervention process. Returning to the original definition of a stroke service by Dennis (1992), physiotherapists must identify their role within the organisation of stroke care and prove that physiotherapists are effective in improving functional outcomes and activities of daily living for stroke patients.

1.4. Summary

This presentation, of both the burden of stroke and its management within acute stroke units, has highlighted a number of key issues of importance to stroke physiotherapists:

- Whilst functional disability can be assessed by existing ADL tools, they are too crude to measure impairment and its resolution and therefore, invalid for measuring the recovery of motor function or the development of compensatory strategies.
- A resulting lack of consensus regarding the true levels of impairment and disability following strokes in the United Kingdom and, therefore, the demand for treatment.
- A lack of consistency in service provision resulting in problematic evaluation of the multidisciplinary teams contribution to reducing the overall burden of care to the National Health Service.
- Inconclusive evidence regarding the effectiveness of stroke unit management in reducing the levels of functional deficit, due to a lack of measurement validity.
- A resulting lack of consensus within leading organisations such as the Royal College of Physicians regarding the effectiveness of care and treatment within of acute stroke units.
- The nature of the disease and the systems potentially effected resulting in numerous pathological categories each with their own clinical presentations,

requiring both treatment and subsequent outcome measurement of impairment and disability at the level of the individual patient.

- The use of the randomised controlled trial may not be the most appropriate research design in stroke unit evaluation as they may eliminate, through standardisation and selection criteria, the components of clinical practice that produce the effect.

CHAPTER 2

2. STROKE REHABILITATION

One third of patients will survive the acute phase following a stroke (Wade, 1992a) and it is these patients with their residual deficits who will require rehabilitation by the rehabilitation team. It would appear from Diller's presidential address at the American Congress of Rehabilitation Medicine (1989), that the founder of the concept of multidisciplinary rehabilitation was Howard A Rusk (Diller, 1990). His vision was of a team of people from different disciplines, identifying and ameliorating the biomedical, psychological, vocational and social needs of individuals with severe physical disabilities. This became the foundation of the medical rehabilitation team from which the stroke team has evolved.

Much work has been undertaken to provide a working definition of rehabilitation. A report by the West Midlands Regional Health Authority, quoted by Evans and Skidmore in Wood and Eames (1989) suggests that:

'Rehabilitation is a process intended to enable a disabled person to play an active, independent and satisfying part in every day life as possible.'

Evans and Skidmore (1989)

Whilst this definition and the principles for the rehabilitation of stroke are well established (Garraway, 1985; Peszczyński et al., 1972; Joint Committee for Stroke Facilities, 1972; Dombovy et al., 1986), there continues to be considerable dispute regarding the composition of the rehabilitation teams and their effectiveness.

2.1. Rehabilitation Teams

In Brown's (1982) historical review of the development of the rehabilitation team, he suggests three phases through which the teams have evolved. The first phase being the pre-war medical movement away from the role of the general practitioner to the more specialised role of the medical physician. The second phase was in the post-war period, as medical knowledge developed, it became apparent that the newly developed

specialities required some form of organisation. Brown continues his theories of development by making the suggestion reiterated by Keith (1991) that:

'In the egalitarian climate of the 1960's, the team was seen by allied health workers as a means to promote greater equality of status and to enhance the prestige of its members.'

Keith (1991) (citing Brown, 1982)

The final phase, which Brown suggests has been reached, is that in which the team now practises, with little evaluation of either team function or delivery of care. This may in fact be quite true. Few papers have considered the effectiveness of the multidisciplinary team. Nagi (1976) and Keith (1988) suggest, that most research relates to team dynamics and relationships rather than the effectiveness of the different disciplines within the rehabilitation process. This again supports the previous discussion regarding the lack of evidence of effective intervention.

Brown's theory however, regarding the evolution of the multidisciplinary team, demonstrates a considerable lack of insight into the individual therapy professions. Rusk, saw the development of the interdisciplinary professions not as an attempt at developing prestige and equality but rather as a result of patients multifarious needs. In his presidential address to the 66th Annual session of the American Congress of Rehabilitation Medicine, Dillar (1990), suggests that Howard's view, unlike that held by Brown, was that the individual disciplines were:

'driven by the nature of the problem and not by external dictum.'

Dillar (1990)

The *'nature of the problem'* that has, in Dillar's view resulted in the development of the multidisciplinary team, can be understood by examining the framework within which rehabilitation occurs.

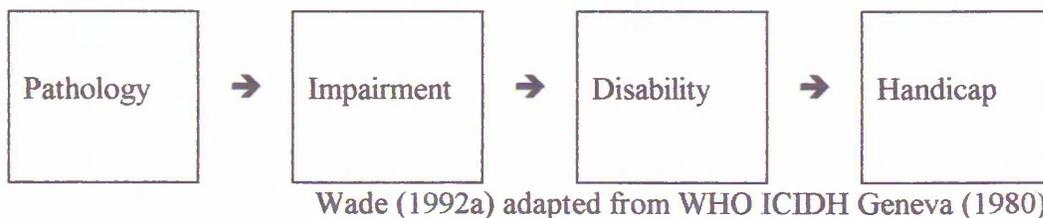
2.2. Models of Disablement

Within the framework of rehabilitation there are a number of models of disablement that enable the hierarchical structuring of the effects that the disease such as stroke might have on the individual. This then allows the identification of the problems that a stroke patient may experience, the nature of the problem that has resulted in the development of the multidisciplinary team. By reviewing these models the rehabilitation process and the problems facing the rehabilitation team become more clear.

Shumway-Cook (1995) in her book on Motor Control identifies a number of models of disablement of which two are of particular relevance to this study. The first is that previously mentioned and developed by the World Health Organisation (WHO Geneva, 1980) in which the effects of the disease pathology is divided into the resulting impairment, disability and handicap. See Figure 1.

FIGURE 1

World Health Organisation Model of Disablement.



Wade in his book on measurement in neurological rehabilitation (1992b) defines rehabilitation based on this model as being:

'a problem-solving and educational process aimed at reducing the disability and handicap experienced by someone as a result of a disease, always within the limitations imposed both by available resources and by the underlying disease.'

Wade (1992b)

He also suggests that hospital attention, presumably medical, tends to be focused on pathology and that, over time, attention shifts towards the disability and handicap moving from the patient to the environment. Wade continues by stating (1992c) that the goal therefore of stroke rehabilitation is to:

'maximise the patient's fulfilment and his independence in his environment, all within the limitations imposed by the underlying pathology and impairment and by the available resources,. and to help the person to make the best adaption possible to any difference between role achieved and roles desired.'

Wade (1992c)

There are a number of problems with this definition of rehabilitation and the identified goals of rehabilitation as they both demonstrate a lack of knowledge of the theoretical basis of stroke physiotherapy. It implies that the mechanisms of rehabilitation are ones of compensation for imposed limitation and not recovery and potential remediation.

A model of disablement should reflect current theories about recovery of the CNS. Bach-y-Rita (1989) claims that the damaged CNS has the capacity to adapt and change in response to environmental stimulation. During physiotherapy, this is implemented by facilitation of normal movement rather than compensatory strategies (Held, 1993). Finger et al., (1988) clearly separates the two neurophysiological mechanisms suggesting that:

'a brain - damaged subject may solve a task and superficially appear to have recovered, yet the subject may be solving that task quite differently because he really has not recovered.'

Finger et al., (1988)

Animal studies by Goldberger (1974) demonstrated that the apparent '*recovery*' of an abnormal grasp reflex in monkeys following motor cortex lesions was in fact achieved by using behavioural programmes that differed from those used by normal animals. As previously presented there is experimental evidence (Lashley, 1924; Guth, 1974) to support the notion that the learning of compensatory strategies may reduce the potential for normal recovery (Le Vere and Davies, 1977). Le Vere (1980) summarises his extensive review of the recovery of function after brain damage stating:

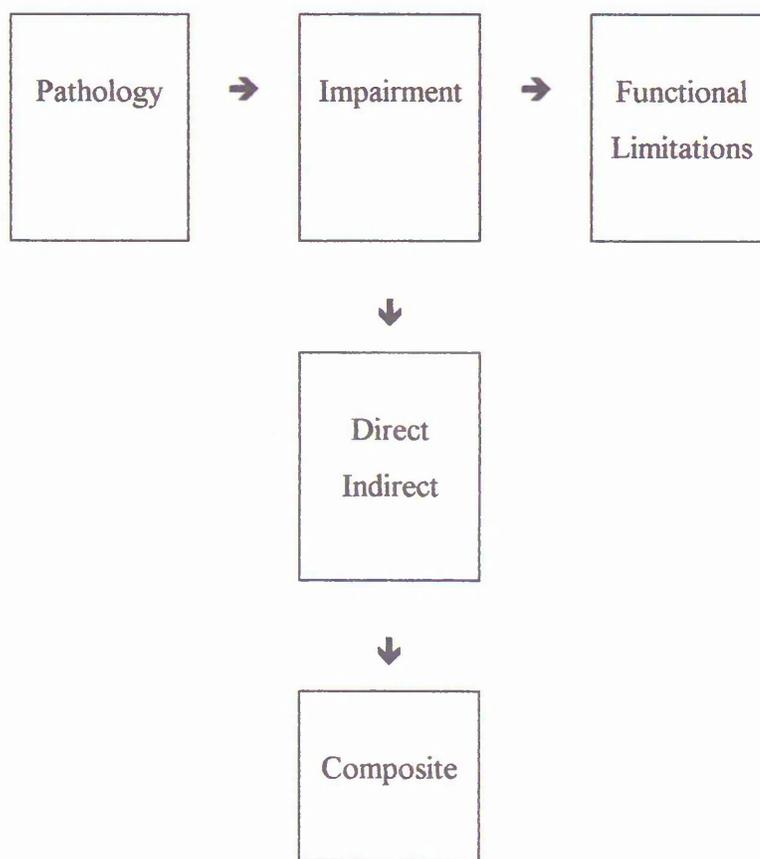
'Accordingly, to maximise recovery of function that is, recovery of those specific preoperative behaviours disrupted by a particular brain injury-one must minimise compensation.'

Le Vere (1980)

With this concept in mind, it is essential that a model of disablement is used, to develop measuring tools or plan rehabilitation strategies, that fulfils the theoretical basis of current physiotherapy practise. One such model presented by Shumway-Cook and Woollacott (1995) was developed by a physical therapist, Margaret Schenkman and is known as the Schenkman model (1989). Whilst rather a complex model covering a biomechanical, and neurophysiological approach Schenkman identifies three aspects of impairment that are the result of the initial pathology. See Figure 2.

FIGURE 2 (a)

Schenkman's Model of Disablement



Adapted from Schenkman (1989)

This model of disablement would best suit the conceptual models of stroke physiotherapy. By further subdivision of impairment into direct, indirect and composite effects of stroke, it reflects both the theoretical basis of therapy and the clinical process required to rehabilitate the CNS following a stroke. The important distinction for physiotherapist identified by Schenkman is that between the direct effects of the

impairment such as spasticity and the indirect effects of these impairments such as muscle shortening and joint contractures. The composite effects are the development of compensatory mechanisms such as overactivity and fixation within the apparently non affected side of the body. Schenkman suggests that the secondary or indirect impairments are a result of the direct or primary impairment and not the pathology itself. As Shumway-Cook and Woollacott state, these indirect or secondary effects of stroke can be prevented by treatment, promoting recovery as opposed to Wade's concept of management within *'the limitations imposed by the underlying disease.'* Wade (1992c).

This model clearly suggests that the role of the physiotherapist is to assess and identify the direct limitations of the disease process such as abnormal tone or unilateral spatial neglect and, by definition, treat them and the indirect effects of these impairments, such as soft tissue contractures and musculoskeletal malalignment. The model therefore implies both a biomechanical and neurophysiological basis to stroke rehabilitation.

The protagonists of the Bobath Approach to stroke rehabilitation (Bobath, 1990; Davies, 1985; 1990; 1995; Partridge et al., 1993) suggest that the physiotherapy process involves not only remediation and prevention of the indirect effects of the stroke, but that the physiotherapy process can also effect the direct disorganisation resulting from the initial CNS damage (Kidd et al., 1992).

In their book on neuromuscular plasticity, Kidd et al., present evidence (Steward, 1989; Matthies, 1989; Agnati et al., 1988; Kaplan, 1988) of the central nervous system's ability to respond and adapt to both inter cellular and extra cellular changes suggesting that:

'In physical rehabilitation this adaption could lead to abnormal movement but if guided the adaption could be to a normal pattem of activity. The ideas in this book lead to the adoption of a particular approach to therapeutic intervention; one aimed at achieving normal movement and reinforcing that normality.'

Kidd et al., (1992)

This implies that any physiotherapy approach based on the use of normal movement to *'guide'* the CNS adaption is able to effect both the direct effects of the stroke and the

indirect effects resulting from the stroke. In her foreword to Kidd's book *Mary Lynch*, Senior Bobath Tutor, writes:

'Imagine a central nervous system you can mould and change through your hands. Imagine a spinal cord you can talk to and indeed converse with. Imagine being able to gain recovery of function after neurological or neuromuscular insult. Now stop imagining and enter a new world.'

Mary Lynch (1992)

Following this argument it is likely, that existing models of disablement, including the Schenkman model, may require adapting in the light of changing knowledge about the CNS's ability to respond to environmental information. It is more likely that the physiotherapy process involves either changing or preventing changes that have occurred as a direct or indirect effect of the disease;

'Techniques recommended to reinforce beaming should be of help when used alongside techniques used to facilitate normal movement.'

Kidd et al., (1992)

None of the models of disablement appear to fulfil the theoretical basis of contemporary physiotherapy approaches such as the Bobath Approach and the Motor Relearning Approach developed by Carr and Shepherd (1985). A number of authors (Parry, 1982; Wade, 1992b; Enderby, 1992; Enderby and Kew, 1995) have suggested using the WHO classification of IDH as a framework for developing and evaluating measuring systems used in neurological rehabilitation. However, the model must reflect the true nature of the physiotherapy process if it is to be a valid model against which to evaluate measuring systems.

Enderby (1992) has developed a measure for use in speech and language therapy using classifications of impairment, disability and handicap within the scoring system. Whilst this method may be useful as a global measure or assessment tool, it has been suggested for use in physiotherapy outcome measurement (Enderby and Kew, 1995). As previously presented, stroke may be the result of a number of pathologies involving a number of

different neural structures, the resultant impairments being numerous. Similarly the resulting disability and handicap may vary between patients reflecting individual needs.

Reviewing the Enderby scale, it would appear that some of the definition may have a number of potential items. An example of this can be seen in their article on outcome measurement in Physiotherapy (1995) where a disability score of 2 includes the following functional skills:

FIGURE 2 (b)

Measuring Disability the Enderby Method

Assistance in some tasks
Transfers with one helper
Walking with maximal assistance
Restricted in all activities because of pain
Unsupported sitting
Supported standing.

From Enderby and Kew (1995)

Whilst this may be appropriate as an initial assessment tool it is not suitable as a measure of change during intervention. A patient may improve in one of the items, deteriorate in another and remain the same in another and have no change on their overall impairment, disability or handicap score. The indicator including components that measure cognitive, musculoskeletal and neurophysiological impairments. This lack of uniqueness and independence of items will result in a lack of responsivity and a failure to provide useful information about effective practise.

Wade (1992 b) states that the construct validity of a measure requires that the results obtained from a measure should '*concur with the results predicted from the underlying theoretical mode.*' However, the framework identified by the WHO may not reflect the present therapeutic process occurring during neurological rehabilitation, and, whilst a valuable framework for assessment tools, it requires modification if used to evaluate measuring systems. These issues, and the factors that might influence the recovery of function following a stroke, are central to establishing the effectiveness of physiotherapy intervention and evidence regarding the prognostic indicators for functional recovery.

2.3 Factors Affecting Potential For Recovery Of Function Following a Stroke.

Numerous studies have attempted to establish the prognostic indicators for functional recovery following stroke however the factors associated with poor outcomes are far from clear. Wade et al., (1985) found that in a group of 99 patients, urinary incontinence present between 7 and 10 days post stroke was associated with poor survival (chi-square = 5.3 ; $p < 0.05$) and an increase in the level of disability at 3 months. There is no chi-square value for the relationship between dependence and incontinence although a p value of < 0.05 for all functions recorded is stated.

In the study of 976 patients Wade and Langton Hewer (1987) use a multiple regression analysis to establish the prognostic indicators for recovery. This is an inappropriate method of analysis as it requires at least an interval measuring scale in order to produce statistically valid results (Aitman, 1995). Of all the measures used in this study, including the Barthel Index, Motricity scores and sitting balance, only age fulfilled this requirement, therefore the results are invalid. Wade's (1985) earlier findings however, have subsequently been confirmed by Gelber et al., (1994) in their study of urinary retention during the first 24 hours following a stroke.

The results of Wade's studies also suggested that age, correctly analysed, was an important prognostic indicator of functional recovery; however, in their review of studies associating increasing age with poor outcomes Jeffery and Good (1995) suggest that this is less clear. This lack of agreement between studies may in part be due to the method of measurement of functional recovery used to identify associations between age and prognosis in this domain. It is unclear whether the functional status of the patients is achieved as a result of recovery or their ability to compensate for loss of function.

Nakayama et al., (1994) using the Barthel Index to measure levels of residual disability suggested that whilst older and younger patients had the same degree of neurological recovery, older patients demonstrated a lower level of improvement on the Barthel Index. Kaira (1994) also found that younger patients had higher Barthel Index scores than older patients in a study of 245 patients randomised to either stroke units or medical wards. As it would appear that the Barthel Index may not measure '*normality*' it is difficult to establish the clinical significance of this information .

Jeffery and Good (1995) reinforce this problem by suggesting that the reported 7% decrease in total Barthel score gain for every 10 year increase in age found by Nakayama et al., (1994) may be due to the fact that older patients have '*less compensatory ability than other patients.*' This view supports the earlier presentation that the Barthel Index is a measure of compensation rather than a measure of the patient's recovery. Indeed further studies have presented conflicting reports of association between age and recovery, Borucki et al., (1992) also using the Barthel Index found evidence of a difference between age and total Barthel scores.

Jeffery and Good (1995) suggest that age and severity of stroke at admission may, in combination, determine functional outcomes. Reporting a study by Alexander (1994), in which admission severity and age interacted to reduce the probability of home discharge, Jeffery and Good summarise by stating the older more severely involved patients tend to benefit less from rehabilitation. This research will be discussed in the light of the findings of this study where the levels of severity were recorded at admission using the National Institute of Health Stroke Scale (Brott et al., 1989) and the Rankin handicap scale (Rankin 1957).

Wade et al., (1987) also reported that the functional ability and sitting balance were prognostic factors to recovery. Using the multiple regression analysis of Barthel scores, Motricity Index scores (Demeurisse et al., 1980), visual fields, IQ, sitting balance and cogitative function, they found that good sitting balance had the worse outcome. This is clinically highly unlikely and in contrast to previous studies (Prescott et al., 1982). It might be suggested that the inappropriate method of analysis, discussed earlier, may have contributed to Wade's (1987) unusual findings.

Riddoch et al., (1995), in their review of prognostic indicators for functional recovery, present conflicting reports of the effect of lesion site on levels of recovery. Denes et al., (1982), in a study of unilateral spatial neglect following stroke, found that patients with right sided brain damage (RBD) took longer to become independent than patients with a left sided brain damage (LBD). Wade et al., (1984) using the Barthel Index to measure levels of disability found that patients with a LBD attended rehabilitation for longer and had better Barthel scores than RBD patients. They state that the longer stay was probably a reflection of the speech therapy requirements as apparently these patients

were not receiving physiotherapy during this period. However, in conclusion, Wade states that the side of the lesion did not affect physical outcomes even though they reported higher Barthel Scores at discharge in LBD patients. The conflict between summary and evidence in this study make it difficult to establish whether Wade et al., were agreeing or disagreeing with the findings of Denes et al.

The question of unilateral spatial neglect and functional prognosis has also received considerable attention in the literature. Denes stating that this impairment is found more frequently in RBD patients and that it '*seems to be crucial in hampering their performance.*' On closer inspection however the sample studied was only 12 with 8 RBD patients having unilateral neglect and 5 LBD patients not conclusive evidence of a relationship between hemispheres and the presence of neglect. Using a modified ADL scale developed by De Lagi et al., (1960) Denes states that LBD patients improved more than RBD patients, however as the ADL scale included 8 areas of motor skills, personal hygiene and feeding the final mean scores being used to obtain a t value it is impossible to establish what the actual difference between the left and right lesion sites were. The effects of lesion site on functional recovery and the research literature reviewed will be discussed further in the light of the findings of this study.

From the literature review it can be seen that a number of authors have attempted to establish links between factors such as age and severity of initial impairment and functional outcomes. However, the review has identified a considerable lack of consensus regarding the prognostic indicators for functional recovery. This may, as Blanc-Garin (1994) suggest, be due to the inter-individual variations between subjects together with the multi-faceted nature of recovery and or compensation or it may, in part, be due to the validity and reliability of the measures used.

Any study therefore into the effectiveness of either therapeutic interventions or comparisons of service provision and outcome must ensure that measures of effect are used that are patient orientated, reliable and valid. A further issue requiring review pertains to the concept of spontaneous recovery as there appears in the literature, to be conflicting opinions (Lind, 1982; Smith et al.,1981), regarding this process and the recovery of functions attributable to physiotherapy intervention.

2.4 Spontaneous Recovery

'Spontaneous: occurring through natural processes without outside influence.'

Collins English Dictionary (1993)

As stated a certain amount of controversy exists regarding the occurrence of '*spontaneous recovery*', changes occurring in a patient post stroke frequently being attributed to this phenomena rather than therapeutic intervention. In a paper by Lind (1982), reviewing seven studies of stroke rehabilitation, he concludes that the recovery that occurs in the first few weeks following a stroke is the result of spontaneous recovery and not therapeutic intervention. Gresham (1986) reinforced this issue in his discussion of methodological difficulties in stroke research. He suggests that all outcome research should mandatorily supply information regarding date of onset and length of time between onset and the commencement of treatment to enable some clarification of the issue of spontaneous recovery versus treatment effect.

A more in-depth critique of Lind's paper does however suggest that his conclusions may be flawed. He attempts to compare the results of four prospective non-controlled studies of which three found rehabilitation to be effective, with three apparently controlled studies that found no effect. Firstly it can quite clearly be seen that two of the three apparently controlled groups did in fact receive '*physical therapy given by a registered therapist*' this input being compared with a multidisciplinary team approach, and secondly the reported correlation between time elapsed and functional recovery was $r = 0.14$, the strength of this correlation being only 19.6%. Without doubt the data provided by these studies would suggest that recovery following stroke may be attributable to both natural recovery and to therapeutic induced recovery however there is no evidence to suggest the relation between either processes or the timing of the intervention.

Interestingly Ernst's (1990) identifies the Smith et al., study (1981), in which 133 stroke patients were randomly allocated to one of 3 groups each receiving different rehabilitation programmes. One group received intensive rehabilitation, one conventional rehabilitation and the third no routine rehabilitation, the patients being visited at home by a health visitor. Of these patients maximum benefit measured on a

functional index of activities of daily living (ADL) occurred in the first three months in the intensive rehabilitation group. Interestingly the difference between intensive rehabilitation and conventional rehabilitation was not in the type of input, both groups receiving physiotherapy and occupational therapy, but in the intensity of rehabilitation. Group one received 4 full days rehabilitation and group 2 three half-days of rehabilitation. Smith states:

'There is little doubt that decreasing amounts of treatment were associated with a greater tendency to deteriorate.'

Smith et al., (1981)

Using the English Dictionary definition of '*spontaneous*' it might be suggested that the recovery of function early on in the rehabilitation may be the result of '*natural processes*' induced by the original insult as opposed to recovery induced by external influences. The implication for the stroke physiotherapist being that if clinically significant change can occur during the natural processes induced by the original insult, why bother treating the patient during this period? For the researcher, what functional recovery is attributable to natural process and what to external influences such as drug treatments and physiotherapy intervention? Perhaps more importantly, do physiotherapists contribute to the natural processes and what might be the outcome of spontaneous recovery if this occurred in the absence of physiotherapy? Is Ernst correct when he cites Johnson's (1983) belief that :

'stroke rehabilitation is far more preferable to spontaneous recovery.'

Ernst (1990)

In order to address these questions the neurophysiological mechanisms underlying the functional recovery from stroke need identifying. Following the initial injury to the CNS Held (1993) suggests the resulting symptoms may be due to two phenomena, cell death caused by the insult and a secondary shut down of neural activity near to or associated with the area of damage. This concept was first identified by Von Monakow (1914: translated by Primbam, 1969) and became known as diaschisis. An assumption of Von Monakow's theory was that the shut down or neural shock can occur along specific pathways associated with the original or primary area of damage. Finger (1978)

describes the resulting total lack of function during this period suggesting that oedema, disruption of local blood flow, or partial denervation of the post synaptic neuron are possible causes of the phenomena.

Dombovy and Bach-y-Rita (1988) suggest that recovery from this state of diaschisis is therefore the resolution of these local responses to injury and include resorption of oedema and the development of collateral circulation to the local areas of ischemia. They continue by citing Brodel (1973) who having suffered a stroke himself suggests that these mechanisms '*cannot account for recovery occurring beyond 1 to 2 months.*'

Luria (1963) presented a theory very similar to that of Von Monakow the fundamental difference being that the neural shock or '*inhibition*' is a more diffuse phenomena that can affect the whole brain. Luria suggested that specific training could '*hasten*' this natural process by disinhibition of synapses.

Finger et al., (1988) support the view that initial recovery of function within the first few days or weeks may be the result of resolution of local ischaemia however suggesting that both mechanical, that is the removal of an obstruction, and pharmacological intervention may promote the healing process. Using the original definition of '*spontaneous*' as being natural processes it can be seen that pharmacologically induced recovery is not spontaneous recovery as it is partially attributable to external influences. In a similar way it might be suggested that physiotherapy intervention promotes or enhances the natural processes initiated in response to the insult.

There is no evidence in the literature that this occurs however, there is evidence in the literature that regrowth of axons may occur in either an orderly or disorderly manner (Kupferman, 1979; Steward, 1989). Steward suggests that humans may learn to use inappropriate connections, citing research carried out by Kohler (1964) on the visual perceptions of humans. In these experiments, subjects who wore lenses that inverted the visual image, adapted to this distorted image becoming able to achieve visually guided tasks to the point of being '*near-normal*'. In rehabilitation terms this relearning and guiding of orderly regeneration may be one of the mechanisms by which the physiotherapist rehabilitates normal movement, however there is no evidence of this in the literature.

Following the initial period of diaschisis Dombovy and Bach-y-Rita suggest that two further mechanisms known as unmasking and axonal sprouting (Schoenfield and Hamilton, 1977) are the likely neurophysiological processes responsible for recovery enabling the development of new pathways and synaptic connection. Steward (1989) similarly supporting this concept in his presentation of evidence of recovery mechanisms following injury suggests a differentiation between axonal sprouting as being the neurophysiological response to denervation and '*reactive synaptogenesis*' or '*regenerative sprouting*' that occurs in response to axonal amputation.

This ability of the CNS to change its '*structural organisation and function*' Dombovy and Bach-y-Rita (1988), has become known as neuroplasticity. Whilst these mechanisms, are well documented what is perhaps less clear is the link between these recovery processes and the therapeutic process. They are theoretically the mechanism physiotherapists seek to induce during the rehabilitation process however, there is little evidence of this in the literature.

Whilst there is this lack of evidence of the physiotherapist role during the initial days following a CVA there is evidence that this neuroplasticity can be maladaptive (Bach-y-Rita, 1989) and that this may be the process that result in compensatory strategies. This concept of recovery as opposed to compensation presented earlier in the fight of measurement validity has the support of a number of authors (Finger et al., 1988; Le Vere, 1980; Held, 1993) and indeed may be a crucial concept when discussing various treatment programmes used in stroke rehabilitation.

Finger et al., (1982) defined recovery as being : '*a theoretical construct that implies a complete regaining of identical functions that were lost or impaired after brain damage*' however it has become clear that patients may not recover but learn to compensate for lost neural circuitry. This learnt adaptive behaviour may in fact be the result of spontaneous recovery not mediated by external influences such as appropriate therapeutic processes and as presented earlier may limit the patients potential for recovery. This concept will be discussed in the light of the results of this study.

Whilst some of the mechanisms underlying spontaneous recovery, recovery and compensation have been described the relationship between the therapeutic processes used in stroke rehabilitation and these mechanisms of CNS reorganisation and regeneration is far less apparent. What is clear is that without intervention the CNS may adapt in Balliet's (1989) words, a relatively abnormal and inefficient '*compensatory motor behaviours*' to correct for the motor dysfunction resulting from the injury. Furthermore as Balliet suggests if goal directed behaviour involving selective motor training in a '*non compensatory training paradigm*' takes place the mechanisms of neuroplasticity may have a higher probability of occurring. Whether an approach exists that fulfils Balliet's concept of rehabilitation will be discussed in the light of evidence provided by this study.

2.5 The Effectiveness of Different Physiotherapy Approaches

A report by the Kings Fund 1988 on the treatment of stroke patients highlights an apparent lack of consensus on the most appropriate therapeutic method as the report states that:

'There is a striking lack of convincing data on the effectiveness of widely used medical, psychological and specific rehabilitation treatments.'

Kings Fund Consensus Conference (1988)

Whilst a review of the literature revealed an array of different approaches to the treatment of stroke patients in the UK (Ashburn, 1993), the most commonly taught and used approach is the Bobath Approach (1990) (Borgman, 1991). This view is supported by Riddoch (1995):

'In general, in the UK, the treatment for neurological patients has largely been based on Bobath principles although elements of the other methods may also be incorporated'

Riddoch (1995)

In a survey of 331 stroke physiotherapists in Australia (Carr et al., 1994) 18.4% of undergraduates said they were taught a pure Bobath model of stroke rehabilitation and in

a similar study in Sweden 40% of undergraduates. In the Australian study when those respondents who ticked more than one approach were further analysed by Carr et al., (1994), 90% identified the Bobath Approach as that being taught at undergraduate level. In an analysis of treatment choice 86% of the Australian physiotherapists reported the use of function activities and facilitation of inhibition, both basic components of the Bobath Approach. These studies serve to illustrate not only the national but also the international status of the Bobath Approach.

Whilst this study has yet to be replicated in the UK it might be assumed the figures would be even higher there as the Bobath concept originated in London and the British Bobath Tutors Association (BBTA) is an organisation running basic and advanced courses in the UK. Table 7 shows the numbers of postgraduate physiotherapists trained each year by the BBTA, although this information does not include weekend courses also run by the association.

TABLE 7

Frequency and Duration of Postgraduate Bobath Courses

<u>Type of Course</u>	<u>Number of Students</u>	<u>Frequency/Year</u>	<u>Duration</u>
Advanced	20	6	1 week
Basic	20	8	3 weeks
Total students trained per year	280		

Because of the predominance of this training in the UK the purpose of this review will be to ascertain what evidence there is supporting the use of this physiotherapy approach in the rehabilitation of stroke patients. Despite an extensive and up-to-date search of the literature on evaluations of the Bobath Approach, only seven studies were identified one of which (Wade et al., 1992) does not clearly identify the approach used, although the principles applied could have been those of the Bobath Approach. For this reason this paper will be included in the review. It is also known that a study evaluating the Bobath Approach and the Carr and Shepherd approach (1987a) used extensively in Australia is being designed and implemented by the Nottingham Stroke research centre, however further details are not known.

The summary in Table 8, of the seven studies reviewed, implies that there is no evidence of a difference between the Bobath Approach and a variety of other approaches researched. However, as with the evidence regarding the effectiveness of stroke units, the papers need to be critiqued in order to determine how the authors arrived at their conclusions regarding a lack of evidence.

Having established that there is some evidence of the value of early intervention both in the recovery of normal function and in the prevention of compensatory mechanisms, the papers in table 8 will be reviewed in respects of timing and frequency of treatment given. The methods used to measure the outcome of interventions will also be reviewed as the previous presentations demonstrated serious concerns regarding the validity of the measures used to record normal recovery as opposed to compensatory mechanisms.

With the exception of the study undertaken by Wagenaar et al., (1990) in which treatment was initiated five to six days post stroke, the start of therapy ranged from sixteen days post stroke to twelve months in the other five studies. The only paper clearly defining the actual intensity of the treatment input was the study by Dickstein et al., (1986) in which the patients received treatment five days a week, each session lasting between thirty and forty-five minutes each. In clinical practise patients are treated daily, weekends excluded, and treatment usually commences shortly after admission to the stroke unit. It is difficult to establish therefore whether any of the studies clearly reflected clinical practice.

Where Dickstein et al., (1986) did appear to use an appropriate treatment regime, the measurement of treatment outcomes were the Barthel Index, muscle tone using a scale developed by the authors that had no proven validity or reliability, selective motor activity at the ankle and wrist on the affected side and ambulatory status using an ordinal scale presumably developed by the researchers. Only the Barthel Index and the gait scale data were used in the analysis, it might be assumed that the other two measurements failed to provide any useful information.

TABLE 8 A Review of the Literature on the Effectiveness of the Bobath Physiotherapy Approach to the Rehabilitation of Stroke Patients

Reference	Approaches compared	n	Mean Age (Yrs)	Start of Rehab	Duration of Rehab	Measures Used	Outcome of Study
Dickstein et al., 1986	Conventional Exs vs PNF & Bobath	131	70.5	Av 16 days post stroke	6/52 each	Barthel Index	No evidence of a difference
Loggigan et al., 1983	Conventional Exs vs Rood & Bobath	42	61.6	Within 7/52 post stroke	n/a	Barthel Index & manual muscle strength test	No evidence of a difference
Lord & Hall, 1986	Conventional Exs vs Bobath	19	n/a	Within 8/12 post stroke	n/a	Phone questionnaire	No evidence of a difference
Basmajian et al., 1987	Behavioural Cognitive Therapy vs Bobath	29	62	Within 12/12 post stroke	5/52 each	Upper limb function tests	No evidence of a difference
Wagenaar et al., 1990	Brunnstrom vs Bobath	7 (single case study)	n/a	5 - 9 days post stroke	5/12 each	Gait Analysis ARA test Barthel UROPSOM	No difference except one patient improved gait in Brunnstrom group
Partridge et al., 1990	Cryotherapy vs Bobath	65	64	Av 33/52 post stroke	4/52 each	Pain scale. Range of movement	No difference except in frequency of pain both groups
Wade et al., 1992	Post 3/12 Bobath	94	72	12/12 post stroke	Av 14/52 4 treatments/wk	Frenchay Activities Index Gait Speed Nottingham ADL Index Barthel Index	Mobility improved

A.R.A. Test (Lyles et al., 1984) Action Research Arm Test
UROPSOM (Van Roogen et al., 1984) Dutch Version of Depression Adjective Check List

Using summed Barthel scores and sub-group scores, the researchers found no significance between the three groups. A basic concept of the Bobath Approach is the normalisation of tone and the facilitation of normal recovery (Bobath, 1990) however, as discussed previously, the Barthel Index fails to identify the recovery of normal movement, the lack of evidence is therefore not surprising.

The measurement tool used to establish the recovery of independent walking during the three interventions used the following scale developed by the authors:

- patient does not walk
- patient walks with an assistive device and the help of one
- patient walks with an assistive device
- patient walks independently

From Dickstein et al., (1986)

An initial comment regarding this measure relates to its validity as measure of recovery during Bobath treatment as assistive devices are rarely used if ever in the early rehabilitation of stroke patients (Bobath, 1990; Davies, 1985; 1990) and this research took place during the first 6 to 8 weeks of rehabilitation. It is hardly surprising therefore that at 4 weeks more conventional and PNF patients were scoring higher than the Bobath group with 41.8%, 28.6% and 10.5% of patients respectively achieving ambulation with walking aid and assistance. The results at 6 weeks showed no difference between groups although whether there was a difference in how the patients achieved this goal cannot be assessed due to the lack of sensitivity of the measure. This critique highlights the dangers of using poorly validated measures that do not fulfil the theoretical basis of the approaches being evaluated.

The study by Wagenaar et al., (1990) highlights a further problem involving research design in rehabilitation. The authors of this paper used a single case study B - C - B - C design in which Bobath and Brunnstrom treatment were alternated, each block of treatment appeared to last for 5 weeks. This research design is extremely questionable as the two approaches rely on opposing mechanisms of recovery. The Brunnstrom approach, as identified by Wagenaar : *'facilitates the natural process, in particular by*

encouraging associated reactions in the acute phase after stroke.' The Bobath Approach *'emphasises the facilitation of normal movement and muscle tone by a normal input due to normal postural adjustments and movement.'* (Kidd et al., 1992). In the light of the previous discussion of *'spontaneous recovery'* one treatment approach encourages compensatory strategies, the other normal recovery.

The literature presented earlier would suggest that the effects of *'compensatory training paradym's'* (Balliet, 1989) may limit recovery of normal function (Le Vere, 1988) and it might therefore be argued that the effects of the Brunnstrom phase may have required reversing before the patient could relearn a functional task performed before the CVA. Whilst the results of this study did not show a significant difference between the outcomes from each phase, with the exception of walking speed improvements in Brunnstrom phase, the results are questionable because of the research design. Again the authors used the Barthel index as a measure of outcome and this has been demonstrated to be inappropriate in the measurement of normal recovery.

The study by Lord and Hall (1986) used a telephone questionnaire to establish the effects of physiotherapy and Loggigian using a mixture of Bobath and Rood approaches (Goff, 1969) used not only the Barthel Index but also a manual muscle strength test.

Using a manual measure of muscle power is inappropriate as the researchers may in fact have been measuring spasticity in the stroke patients studied. Spasticity *'a motor disorder characterised by a velocity dependent increase in tonic stretch reflex'* Lance (1980), produces a resistance to movement initiated when the patient attempts to overcome the resistance applied in a muscle-testing situation. The principal aim of the Bobath Approach is to normalise muscle tone with a frequent need to reduce the overactivity of certain muscle groups (Lynch and Grisogone, 1990). The test of strength therefore used in this study may in fact fall as the treatment progresses and spasticity is reduced.

Another major problem for stroke physiotherapists is the lack of knowledge that researchers appear to have of the evolution within the Bobath Approach (Gerber, 1995). It might be anticipated that the earlier studies on the Bobath Approach (Loggigian et al., 1983; Dickenstein et al., 1986; Lord and Hall, 1986) may not have been aware of the

changing nature of the approach particularly as there has been a lack of published information on the Bobath Approach (Ashburn, 1995). However more up-to-date papers such as Wagenaar et al., (1990) appear to have no knowledge of the present state of the approach:

'In Neurodevelopmental therapy (ND7) being a modernised version of Bobath) the patient beams to consciously exert control over his or her muscle tone during activities of daily life mainly using 'reflex-inhibiting patterns of position (RIP)'

Wagenaar et al., (1990)

Patients are no longer trained to '*consciously exert control*' over tone and the use of reflex inhibiting patterns have not been taught by the Bobath tutors group for a considerable number of years. Berta Bobath clearly identified this change in the 3rd edition of her book entitled Adult Hemiplegia in which she states:

'We have discarded all static ways of treatment like the 'reflex inhibiting posture, but have introduced a strong emphasis on movement and on functional' activities.'

Berta Bobath (1990)

This total lack of insight and knowledge of the present state of the Bobath Approach has resulted in the implementation of inappropriate research studies that have failed to provide the evidence so vitally needed of the characteristics of effective physiotherapy intervention for stroke patients. Evidence in the literature, of the evolution of the Bobath Approach will be presented in a subsequent chapter.

2.6 Patterns of Functional Recovery

Because of this lack of research on the effects of physiotherapy there is little available information about the recovery patterns occurring during a specific therapy intervention. In a large study carried out by Partridge et al., (1993), 348 patients were monitored during physiotherapy treatments to establish what patterns of recovery occurred over a six week time period. Although Partridge suggests that the results revealed patterns

previously reported (Partridge et al., 1987) in which the recovery of function demonstrated a 'curve' pattern the study is severely flawed.

Firstly, the method of data analysis used will inevitably result in the loss of valuable information on patterns of recovery as the scores were averaged and any variation from the mean by individual patients will be lost. Whilst the items scored during this study were comprehensive the method of scoring an item such as '*standing-up to free-standing position*' was as follows:

- | |
|---|
| <ul style="list-style-type: none">● "did do"● "did not do" |
|---|

Partridge et al., (1987)

The gross nature of this measure of recovery will miss the clinically significant steps that a patient goes through as they relearn a motor goal such as standing from sitting. The results of this study are in conflict with the view expressed by Bach-y-Rita (1981b) when he discusses how the stroke patient may relearn the components of a motor skill such as gait. Bach-y-Rita cites Kuhn's (1970) theory of learning, as consisting of an acquisition-consolidation phase, the consolidation phase appearing as a plateau in the learning process.

Kuhn suggested that during the consolidation phase of learning the human being is incapable of learning new material. This concept will be reviewed in the light of new knowledge provided by this study regarding the patterns of recovery recorded during the implementation of the Bobath Approach in the rehabilitation of stroke patients.

As Bach-y-Rita suggests the term '*plateau*' is generally used in the literature to imply that learning has ceased, '*upon reaching a plateau the patient is discharged*' Bach-y-Rita (1981b). He continues by advocating further evaluation of this learning process in stroke patients as it may '*offer considerable therapeutic benefits without requiring new theoretical breakthroughs.*' Much of the work undertaken in this study relates to this

concept of relearning components of motor tasks in a non-compensatory treatment paradigm and the results will be discussed in the light of Bach-y-Rita's work.

2.7 Methodological Difficulties in Evaluating The Effectiveness of Treatments

'Randomised clinical trials of new medicines presents a dilemma for doctors, who want results, and patients, who want to be cured.'

Toynbee (1996) The Independent

It can quite clearly be seen from this presentation of stroke as a disease and the rehabilitation of stroke survivors that the very nature of both will create major problems for the researcher. It has been established that the scope and level of impairment may vary following a stroke, as may the timing and frequency of interventions be they drug therapies or physical therapies. The psychological effects of having a stroke (Andrews, 1991), the effects of carry over and the role of the extended care team are all factors that potentially affect the ultimate outcome of treatment.

Whilst certain authors (Ernst, 1990; Dombovy et al., 1986) have suggested that randomised controlled trials (RCT) are the only *'scientific'* way of providing evidence of effective interventions, the evaluation of stroke rehabilitation in this way would be inappropriate for a number of fundamental reasons. Of particular concern are the methods of sampling, randomisation into control groups, sample size and treatment standardisation, all essential components of the RCT.

Following the RCT's on the drug Distaval better known as thalidomide, the drug was marketed in 1958 and used in early pregnancy as a sedative and anti-emetic. On 2 December 1961 Distillers Company Ltd wrote a letter to the editor of the Lancet stating that:

'having just received a report from two overseas sources possibly associating thalidomide with harmful effects on the foetus in early pregnancy..... we feel that we have no alternative but to withdraw the drug immediately from the market pending further investigation.'

Hayman, Managing Director Distillers Company Ltd, Lancet (1961)

The two overseas sources were in fact, single case studies subsequently published as brief letters in the Lancet (Mc Bride, 1961; Lenz, 1962; Pfeiffer and Kosenow, 1962). These medical practitioners noticing an increasing incidence in hypoplastic and aplastic deformities in babies used single case information to establish a link between the drug taken during the earlier stages of pregnancy. There followed two further case studies (Williams and Dunoulin, 1962; Scott Russell and McKichan, 1962) providing further evidence of the effects of the drug. Sadly Lenz (1962) estimated that since the drug was marketed in Germany in 1959 and subsequently withdrawn in 1961 an estimated 3,000 babies may have been born with defects attributable to the drug.

It is easy to imagine how the results of the original RCT could have failed to detect such severe side effects. The numbers of subjects in a trial would have been too small to have had any worthwhile chance of detecting any undesirable or unwanted side effects, which by definition occur relatively infrequently. In addition inclusion in the trial could have introduced bias, as exclusion and inclusion criteria will have potentially removed certain variables which, in combination with the intervention may produce unwanted side effects or indeed in the case of stroke rehabilitation, produced the outcome. Similarly the use of informed consent by its very nature will result in the biasing of a given sample, any one with the slightest risk of developing side effects would not have agreed to participate.

It is interesting that during the RCT of Distaval the decision to stop the research because of side effects did not occur during the trial as data collection processes were incomplete. However following licensing, the decision-making process to withdraw the drug from the market was based on what amounted to single case study information.

A recent article by Toynbee (1996) highlights the increasing dilemma facing researchers using RCT. She suggests in the article that Professor David Machin, a chief statistician for the Medical Research Council, believes that many trials are collapsing as patients do not want randomising into a control group rather than receiving treatment, particularly where this involves life-threatening conditions such as cancer and aids. In many instances practitioners both medical and paramedical, have informal knowledge of effective interventions and to withhold this information has, suggests Toynbee, ethical implications.

A further methodological problem for Bobath physiotherapists lies in the very nature of the approach one of the basic principles of which is the dynamic nature of treatment input changing in response to individual patient's needs. It would be impossible to set a prescriptive, rigid protocol of therapy as might be recommended in the more traditional forms of randomised controlled trials, the aim of which is to control out many of the variables integral to the Bobath Approach. It is the effects of the relationship between therapist and patient in a variety of clinical settings that need to be evaluated. As Andrews (1991) states:

'Unfortunately, from a research point, most rehabilitation research is much more complex than the majority of medical research, no matter how high-powered and 'scientific' the latter appears to be.'

Andrews (1991)

Andrews continues by suggesting that there may be more appropriate methods of implementing rehabilitation research and further comments:

'It is also not surprising that the single case study design has become popular recently in trying to answer the rehabilitation problems'

Andrews. 1991

The single case study design however, has potentially the same problems as the RCT, as the aim of this type of study is to use a period of no treatment as the control period. (Bithell, 1994). This concept is in contrast to that of Robertson and Lee (1995) who support the use of single subject case studies as a method of evaluating and improving clinical practice. A case study does not require a '*control*' period nor does it hope to eliminate certain aspects of the patient's care indeed all aspects must be recorded as the '*units of interest*' in the evaluation. For the reasons identified above, the single case study approach will be used in this evaluation of the Bobath concept, a further presentation of the literature pertaining to the use of this method of treatment evaluation will be included in the rationale for research method in a subsequent chapter.

2.8 Summary

A number of key issues have been highlighted during this literature review, each relevant to both the research undertaken and also to the clinical physiotherapist involved in evaluating their own practise:

- The conceptual framework for the classification of disease and subsequently used to define neurological rehabilitation and develop measuring tools may be inappropriate in the light of current scientific knowledge of the CNS.
- Conflicting evidence surrounding the relationship between spontaneous recovery and recovery induced by physiotherapy intervention compounded by a lack of evidence linking the mechanisms responsible for recovery within the CNS and the therapeutic process.
- A lack of consensus regarding the prognostic indicators for full functional recovery.
- A lack of knowledge regarding the current state of the Bobath Approach with subsequent inappropriate treatment modalities used in research studies.
- A lack of validity in the outcome measurements used to provide evidence of effective therapeutic intervention, with a lack of clarity regarding the measurement of compensation, as opposed to recovery.
- Inappropriate research designs that may result in inappropriate conclusions being drawn.
- A resulting lack of evidence regarding the optimum type or timing of physiotherapy intervention for stroke patients.
- Lack of consensus regarding the patterns of recovery during the therapeutic process.

3. MEASUREMENT IN STROKE REHABILITATION

'In attempting to arrive at the truth, I have applied everywhere for information, but in scarcely an instance have I been able to obtain hospital records fit for any purpose of comparison. If they could be obtained they would enable us to decide many other questions besides the one alluded to. They would show subscribers how their money was being spent, what amount of good was really being done with it, or whether the money was not doing mischief rather than good.'

Florence Nightingale (1863)

There are two important reasons why the quantification of therapy outcomes has become imperative in stroke rehabilitation. The first, relates to the changes that have occurred in the National Health Service (NHS), and the other to the development of a theoretical basis for physiotherapy practice in stroke rehabilitation.

It is very interesting that back in 1863 Florence Nightingale was as aware of the need to gather valid and reliable information in order to be able to establish the links between cost and quality as we are today. Health care professionals have continually striven to find ways of providing clinical data in order to answer questions regarding the effectiveness of therapy. This need has, however, become more imperative over the past decade with the advent of an '*internal market*' philosophy. (Malby, 1995).

This concept first identified by Enthoven (1985), with its accompanying roles of purchaser and provider, came into effect on the 1st April 1991 as a result of the NHS Act (1990) which followed the government white paper '*Working for Patients*'. (1989). This reorganisation resulted in the contracting of provider services, the consequential effect being the development of competition between both trusts and individual directorates within trusts.

As Benjamin (1995) suggests, this changing ethos towards more cost-effective care have inevitably lead to greater scrutiny of health care outcomes. Competition within the

market place between health care professionals has resulted in the urgent need to provide information on quality indicators in order to aid the decision-making process. This idea has been around for some time, Donabedian in 1966 wrote that knowledge of treatment was the ultimate indicator of quality health care. As Payne (1995) writes, the search for outcome measurement is then a natural progression in the quest for quality. She writes:

'In the climate documented by concern for 'value for money', critical review and limited resources, there is a need to demonstrate that professional input results in beneficial outcomes for patients.'

Payne(1995)

Stroke rehabilitation represents a major burden in terms of cost to the NHS. Professor Tallis in his Marjory Warren lecture (1988, published 1989) states that stroke consumes 3% of all disease costs and that between a third and a half of that goes on stroke rehabilitation. Unless therapists can measure the outcomes of intervention, resources will be directed at more cost-effective methods which in the long-term may not provide the best possible outcome for stroke patients. Tallis (1989) suggests that if therapies do not measure then *'our civil servants and political masters will'*. He further suggests:

'The threat is that our administrators, seeking desperately to make cuts without scandal, may see labour-intensive, revenue intensive therapies for which there is little carefully documented evidence of benefit as a soft target.'

Professor R Tallis (1989)

However, measurement of outcomes alone is not enough, when attempting to provide evidence of the benefits of therapeutic intervention. In 1978 Donabedian published a conceptual framework for the evaluation of medical care, that consisted of the structure of the service, the processes undertaken and the outcome of that process. He saw outcomes as being the end product of health care. However, as Bond (1 993) suggests, it is also essential that outcomes are established in relation to the process of care. In this way evidence of attribution can be obtained.

3.1. Definitions and Characteristics of Health Outcomes

In order to establish the relevance of the theory of measurement to the measurement of health outcomes, the characteristics of an outcome must be presented. The problem for physiotherapists and other members of the professional allied to medicine lies in the conflict that appears to exist between their own definitions and subsequent methods of evaluating health outcomes and those of medical colleagues. The UK Clearing House for health outcomes at the Nuffield Institute for Health, University of Leeds, was set up by the NHS Management Executive in association with the Royal College of Physicians. The purpose of the clearing house has been extensive, one of the aims being to *'raise awareness about key issues in health outcome measurement, in particular the issue of attribution.'* (Outcomes Briefing 1994).

In a document on health outcomes produced by the Clearing House (1993) they define health outcomes as being:

'Outcomes, in general, are the results (effects) of processes. They are that part of the situation pertaining after a process which can be attributed to the process.'

Clearing House, Health Outcomes University of Leeds (1993)

This leads the authors to therefore deduce that: *'The irreducible part of this definition is that outcomes are effects. Measurement which cannot estimate effects is not strictly outcome measurement.'* (1993)

Unfortunately these definitions then lead them to an assumption that in order to measure the effect or efficacy of intervention, only two approaches are available to the health care professionals. These are as stated, the randomised controlled trial and the post-hoc multi variate correlation and analysis of variance techniques .

This medical concept of health care measure is in direct conflict with that of the professional allied to medicine. Lohr (1988) suggests quite a different concept of outcome measurement more relevant to physiotherapists and their colleagues. He suggests that the Donabedian definition of outcome, *'direct attention specifically to the*

patients well-being, and *'emphasises individual over groups'* is far more relevant to the measurement of outcome (Lohr 1988). Benjamin (1995) takes this a step further by suggesting that Lohr's interpretation of Donabedian's definition necessitates studies that look at individuals response examining a broad range of outcomes. She further suggests that this concept clearly requires studies that identify the effectiveness of input as opposed to the medical model of studies examining the efficacy of treatments.

Whilst these terms are frequently misunderstood and used interchangeably, their correct definition is crucial to stroke evaluation research. Lohr defines efficacy as being: *'The level of benefit experienced when health care services are applied under 'ideal' conditions'*. (1988) That is the randomised controlled trial situation. However, he defines effectiveness as being: *'The level of benefit when services are rendered under ordinary circumstances by average practitioners for typical patients'*. (1988). Benjamin supports this argument by highlighting the different aspects of what she terms effectiveness research to include quasi-experimental designs, research that emphasises clinical practice and not focused on a narrow range of clinical end points. It is interesting that she suggests that this is what is required by policy makers and service purchaser, not the efficacy research of the randomised controlled trial:

'Policy application may flow more directly from effectiveness research. The emphasis on real practices, providers, and patients leads to greater generalisation of results. The fact that treatments are provided under typical conditions means that cost data Detective of actual practice can be collected and utilised in cost-effectiveness analysis and other cost-based comparisons.'

Benjamin (1995)

It is interesting that Benjamin feels that medical input is often associated with the treatment of pathology whilst the therapist's role is focused on the *'elimination or amelioration of impairment and disability'* (1995) improving patient's functional status and quality of life.

It can therefore be argued that the outcome of stroke rehabilitation is the clinical effectiveness of the process being implemented. Therefore outcome measurement should

be of changes in function and behavioural status, occurring in a clinical setting during physiotherapy interventions in the environment most relevant to the individual patient.

3.2 Clinical and Statistical Significance

The previous identification of the characteristics of health outcomes was inevitably from a clinician's perspective. However health service administrators require group data in order to identify global management issues. When group data is provided from RCT, problems identified cannot be resolved, as the individual's data is lost in the statistical process of analysis. However, where group data is provided from individual case studies advocated by clinicians, any global problems identified can be resolved by reverting back to the individual from the group. In order to fully understand this concept, the term clinical significance and statistical significance must be identified and reviewed.

The term clinical significance is frequently seen in the research literature when the presence or absence of statistical significance is discussed in the light of statistical findings within a group. As Hicks (1995) discusses, any research reporting the statistical significance of data must be critically reviewed to establish whether the patient has benefited clinically. In a group of post-partum women undergoing two different pelvic floor exercise regimes she writes:

'Let us imagine at the end of the study that this latter group was found to have pelvic floor muscles which were significantly stronger statistically, but yet they still suffered a high level of incontinence. It could be said that these results were statistically significant but were clinically meaningless.'

Hicks (1995)

This important distinction is also identified by Altman (1995) in his book on statistics for medical research in which he cites Frieman et al., (1978) who looked at 71 published papers with negative results defined as having p values greater than 0.1. Frieman constructed confidence intervals for each study and found that for half the studies the results were compatible with 50% therapeutic improvement which, as Altman suggests, may *'reasonably be taken as clinically valuable'*. He goes on to state that smaller

studies may also fail to detect as statistically significant a difference that is real to the patient. *'These trials demonstrate the non-equivalence of statistical significance and clinical importance.'* The reason for this goes back to the previous discussion regarding the definition and characteristics of an outcome. Most medical researchers use a reference point for their statistical calculations of 'cure'. A more appropriate outcome, previously established, should be clinically significant change that is, improvement or lack of improvement in a name function or behaviour.

In Testa's paper on the nature of outcomes Assessment in Speech Language Pathology (1995) she discusses the definitions of clinical significance and the relationship between these definitions and research methodology. In her paper she cites Bain's (1991) definition as being:

'a clinician's subjective judgement of the importance of the change observed in a client who is undergoing treatment.'

Bain et al., (1991)

A more objective definition of clinical significance is offered by McReynolds and Kearns (1983) as being:

'the strength of treatment effects,' that is, the clinical or therapeutic relevance of treatment'

Kearns and McReynolds (1983)

From these definitions it can be seen that there are two fundamental components of clinical significance. On the one hand the clinicians judgement of the importance of the observed change, and on the other the relevance or relationship of that change to the intervention. Judgement by clinicians must be based on knowledge and based on that knowledge, change that requires therapeutic input is clinically significant.

The function of statistical significance is to show whether there is enough evidence to draw a conclusion about the differences observed between groups. Is the difference larger than the random difference created by the sample selection? Whilst this method may demonstrate that on average the difference is a real difference, there is no way of

knowing from the group which patients have benefited from the treatment, and which have not. It could therefore be argued that statistical significance may bear no relevance to the effectiveness of interventions for any given individual and that clinically significant change if based on sound theoretical knowledge is a more appropriate reflection of effective intervention and should therefore be used as a measure of health outcomes.

Similarly it might be suggested that the use of group measurement such as averages is limited and whilst it may provide information for administrators, further problem solving processes are hindered by an inability to revert the group data back to the individual. This in contrast to the measurement of clinically significant functional or behavioural change occurring in the individual that can be used, either, as a clinical measure of effectiveness or to provide useful information about groups of patients for effective management of resources.

3.3 Theories of Measurement

'Measurement is one of those terms which has attained a social prestige. Apparently, all other things being equal, it is better to measure than not to measure.'

Churchman (1959)

Having identified the characteristics of appropriate outcome measurement, the theories underlying measurement must be presented to determine how they should be applied to ensure validity. Furthermore, when designing a research study, knowledge of formal measurement theory is required in order to be able to critically review existing measures, or if necessary, to be able to develop an appropriate tool for use in the clinical setting. (Cambell, 1981).

Measurement has been defined by a number of authors. Stevens (1959), whom many see as the original advocate of scales of measurement and their essential properties, defined measurement as being the: *'assignment of numerals to objects or events according to rules'* (1959). Another definition by Cambell N R (1957) states that measurement is: *'the process of assigning to represent properties or qualities.'* Perhaps the definition most appropriate for the stroke physiotherapist is that of Michels who suggests that:

'Measurement is the act of converting observations into data, and includes classification, counting, ranking and quantifying.'

Michels (1983)

If, as previously outlined, clinically significant change is an integral part of any study into the effectiveness of stroke physiotherapy, it might be argued that Michel's definition of measurement supports a concept of using clinically significant change if this could be converted into quantifiable data. Used in a clinical setting *'under ordinary circumstance by average therapists for typical patients'* evidence of effective practice as defined by Lohr (1988) might be achieved.

As previously mentioned Steven's (1959) defined four levels of measurement these being the nominal, ordinal, interval and ratio scales. Clinically significant observations would, using Stevens definitions, be classified as an ordinal scale of measurement. Michels states the definitions of measurements all use the term *'rule'* Hayes (1967) suggesting that this rule is:

'a systematic rule of procedure that permits one to identify each possible event that might occur in the given observational situation with one of a set of different categories or symbols.'

Hayes(1967)

The rules identified by Stevens' in his theory of appropriate statistics are complex however, certain features need to be identified in respect of ordinal scales. As Mackenzie and Charlson (1986) suggest, the rules governing scales of measurement are frequently violated invalidating the results published. In his study he reviewed all trials published in three leading journals between 1980 and 1984 in which ordinal scales were used. In the review, Mackenzie and Charlson frequently identified problems with the uses of the ordinal scale and suggests guidelines for future research.

In view of the fact that most scales of measurement used in neurological rehabilitation and based on the WHO CIDH (1980) are ordinal in nature (Wade 1992 b), the properties identified by Stevens will be presented and discussed in relation to the measurement of

1. Die folgenden Aussagen sind wahr oder falsch? Begründen Sie!

(a) \mathbb{R}^n ist ein Vektorraum über \mathbb{R} mit der Addition $(x, y) \mapsto x + y$ und der Skalarmultiplikation $(\lambda, x) \mapsto \lambda x$.

(b) Sei V ein n -dimensionaler Vektorraum über \mathbb{R} . Dann ist jede lineare Abbildung $f: V \rightarrow V$ durch eine $n \times n$ -Matrix A über \mathbb{R} darstellbar. Ist A invertierbar, so ist f ein Isomorphismus. Ist A nicht invertierbar, so ist f ein Endomorphismus, aber kein Isomorphismus.

(c) Sei V ein n -dimensionaler Vektorraum über \mathbb{R} . Dann ist jede lineare Abbildung $f: V \rightarrow V$ durch eine $n \times n$ -Matrix A über \mathbb{R} darstellbar. Ist A invertierbar, so ist f ein Isomorphismus. Ist A nicht invertierbar, so ist f ein Endomorphismus, aber kein Isomorphismus.

(d) Sei V ein n -dimensionaler Vektorraum über \mathbb{R} . Dann ist jede lineare Abbildung $f: V \rightarrow V$ durch eine $n \times n$ -Matrix A über \mathbb{R} darstellbar. Ist A invertierbar, so ist f ein Isomorphismus. Ist A nicht invertierbar, so ist f ein Endomorphismus, aber kein Isomorphismus.

(e) \mathbb{R}^n ist ein Vektorraum über \mathbb{R} .

(f) Sei V ein n -dimensionaler Vektorraum über \mathbb{R} . Dann ist jede lineare Abbildung $f: V \rightarrow V$ durch eine $n \times n$ -Matrix A über \mathbb{R} darstellbar. Ist A invertierbar, so ist f ein Isomorphismus. Ist A nicht invertierbar, so ist f ein Endomorphismus, aber kein Isomorphismus.

(g) Sei V ein n -dimensionaler Vektorraum über \mathbb{R} . Dann ist jede lineare Abbildung $f: V \rightarrow V$ durch eine $n \times n$ -Matrix A über \mathbb{R} darstellbar. Ist A invertierbar, so ist f ein Isomorphismus. Ist A nicht invertierbar, so ist f ein Endomorphismus, aber kein Isomorphismus.

outcomes using an ordinal scale. The properties identified by Stevens in relation to ordinal scales are connectivity, asymmetry and transitivity.

FIGURE 3

Properties of an Ordinal Scale

Connectivity	Defines the relative position of the properties of the scale, the items denoted within the scale being unique and of a greater or lesser value than each other.
Asymmetry	Defines the relationship between items within a scale, one being of a higher value than the previous item within the scale.
Transitivity	Defines the relationship between items such that if $A > B$, and $B > C$, then $A > C$.

In the development of an ordinal measuring scale if the items within the scale are hierarchical and unique then the scale will fulfil the properties of connectivity, asymmetry and transitivity. Two further requirements of any measure is that it is valid and reliable. As Krebs (1987) states: *'useful and truthful data depend for their existence on scaleable and detectable events being translated into pertinent, valid, and reliable measurements.'* However it is important to note that in quantitative measurements they may be reliable and unbiased but lacking in validity. Michels (1983) confirms this argument when he suggests that : *'No measurement can be valid unless it is reliable, but reliability does not assure validity.'* Figure 4 highlights a number of definitions of reliability and validity, whilst these concepts can be subdivided further they do serve to highlight key features in relation to measuring health outcomes.

The earlier presentation of the characteristics of an outcome measure, resulted in a suggestion that observable clinically significance change that is based on sound knowledge, should be used to measure the effectiveness of therapeutic interventions for stroke patients. One crucial component of this concept being that clinically significant change required to be supported by knowledge. If observable clinical change is used to measure effectiveness, by definition, the measure must have validity. Similarly, if the items within an ordinal scale are based on clinical change, supported by clinical

knowledge, any number of observers, with that level of knowledge, will agree with the items in the same way ensuring the reliability of the scale.

FIGURE 4

Definitions of Measurement validity and Reliability.

<p>VALIDITY</p>	<p>The extent to which a test measures what it is intended to measure <u>Pogar and Thomas (1991)</u></p>
	<p>A valid measure is one which can measure whatever it is supposed to and can achieve the purpose intended. <u>Wade (1992b)</u></p>
<p>RELIABILITY</p>	<p>A measure of reliability may refer to how closely two obtained results relate to each other. <u>Wade (1991b)</u></p>
	<p>The extent to which a test or measurement result is reproducible <u>Pogar and Thomas (1991)</u></p>

In order to improve the reliability of a measuring scale developers frequently broaden the definitions of the scale, an example of this process being the Enderby method (1992) discussed earlier. Referring back to the Figure 2(a), it will be noted that a disability score of 2 covers a number of activities. Whilst this may improve reliability, it will reduce the objectivity of the scale and will result in an inability to record changes that occur during intervention.

In a study of the effectiveness of stroke physiotherapy any measure used must fulfil the requirements of measurement theory briefly outlined above. As previously reviewed, a number of studies have been implemented, refer to Table 8, to determine the effects of

certain types of physiotherapy however, few have produced conclusive evidence. it might be argued that this may be partly due to the method of measurement chosen in the studies. The question of whether they fulfil the theories of measurement, will be discussed further in the main body of this report, as it was the objective of the initial phase of this study to identify the measurement needs in stroke rehabilitation and subsequently choose a measure to be piloted in the second phase.

3.4 Measurement and Theory Development

'The ability to state explicitly theoretical assumptions underlying intervention is a key component in the ongoing process of scientific development.'

Kuhn(1970)

In her paper on physiotherapy in stroke rehabilitation Carr et al., (1994) identify the importance of theory to practice. They suggest, that it is essential to identify theoretical assumptions underlying interventions so that hypotheses can be stated about the effectiveness of treatment interventions and that these hypotheses can then be tested. They suggest, that without this, the evaluation of physiotherapy is difficult. They interestingly cite Palisanos' study (1991) of the effectiveness of the Bobath Approach, suggesting the major problem with the study was a lack of theoretical assumptions and subsequent testable hypothesis. Carr clearly states that:

'Quantitative evaluation of the effects of treatment methods is a necessary component in the development of physiotherapy as a clinical science.'

Carr et al., (1 994)

This view is reiterated by Michels (1983) when he quotes an interesting concept of measurement identified by Kuhn when he states:

'If measurement ever leads to discovery or to confirmation (of theory), it does not do so in the most usual of all its applications. To discover quantitative regularity one must normally know what regularity one is

seeking and one's instruments must be designed accordingly. The road from scientific law to scientific measurement can rarely be bravely in the reverse direction.'

Kuhn (1961)

As Michels states (1983), this idea suggests that theory and concepts are preliminary to measurement and that preparation is required on the basic assumptions of the approach to be measured: '*quantities are of qualities.*' Kaplan (1964).

Therefore, it must be argued that the need in stroke physiotherapy is to identify the theories underlying the approach to be evaluated as a preliminary to the measurement and testing of hypothesis stated. The purpose of the next chapter will be to review the theoretical basis of stroke rehabilitation in order to be able to establish the research assumptions to be tested by this study. From this review it can also be argued, that any measure to be used in this study, must fulfil certain properties if the information provided by the measure is to be meaningful.

3.5 Summary

During this review of measurement in health care, a number of issues have arisen pertinent to the study to be undertaken, these are as follows:

- There is a discrepancy between the established concept of outcomes as being the efficacy of a specific treatment in a controlled environment with identified patients and the measurement of the effectiveness of input in a clinical setting with '*typical patients*'.
- Because of this discrepancy, there is no clear distinction between the effectiveness of input and efficacy of a specific treatment.
- Clinical significance is an essential characteristic when measuring health care outcomes.

- Measurement theory dictates that any measure used to evaluate health care outcomes must have a number of identified properties.
- A quantitative measurement, that is reliable and unbiased may be invalid, however a measurement scale that is based on clinical significant change is valid and reliable if based on theoretical knowledge.
- Theoretical assumptions should be defined before the outcome of an intervention process can be measured.

4. CONCEPTUAL AND THEORETICAL MODELS OF STROKE REHABILITATION

In the previous chapters, the literature regarding the effectiveness of different approaches to stroke rehabilitation was critically evaluated. From this appraisal, it became clear, that there appeared to be little evidence of a difference in terms of functional outcomes between approaches. The review identified that this lack of evidence and overall consensus regarding the characteristics of effective rehabilitation may be due to a number of factors, such as, measurement validity and study design. This was further compounded by an apparent lack of knowledge by researchers (Waagenar et al., 1990) of the conceptual and theoretical bases of the various approaches used. It would seem appropriate therefore, to establish from the literature what the differences and similarities are between the physiotherapy approaches in stroke rehabilitation.

To facilitate this comparison, the conceptual and theoretical bases of movement rehabilitation and movement science will be reviewed. This will allow determination of how the therapy approaches have responded to new knowledge in the fields of behavioural and neurosciences and indicate what evidence there is in the literature regarding the evolution of the various approaches.

Evidence will be presented about developments within the study of motor control and motor learning, establishing the relationship between the behavioural approach and the neurophysiological approach and their move towards an integrated science.

4.1. Theoretical Developments in Neuroscience: An Historical Overview

'During much of the present century, the prevailing notion has been that the mammalian CNS is a static structure whose parts are interconnected in a rigid and unalterable fashion.'

Steward (1989)

Prior to the late 50s and 60s, concepts of CNS organisation and recovery were predominantly influenced by the work of two neuroscientists. In 1861, Broca first published his work demonstrating that there were specific areas in the non-dominant cerebral cortex that related to the ability to speak. This concept of a *'strict point-to-point localisation of function'* (Bach-y-Rita, 1989) led to a belief that the CNS was unable to reorganise in response to injury. Gispén (1993) describing the attitude of the early part of the century states that:

'a rather static view of the nervous system prevailed in which electrical information was thought to be processed through a fixed system of neuronal wires. Once developed and matured, no additional changes in connections took place, and following damage to the system very little, if any, repair occurred.'

Gispén (1993)

This early concept of the CNS lent itself to the compensatory, biomechanical, orthopaedic strategies used for stroke rehabilitation prior to the development of neurophysiological approaches.

In 1928, Ramon Y Cajal published the results of his experimental work suggesting that growth was not possible in the neurones of adult mammals (Steward, 1989). It was not until the late 50s that work carried out at the University of Pennsylvania challenged this theory by demonstrating that neural tissue could in fact grow following injury (Lui and Chambers, 1958). Whilst this study did not demonstrate the ability of axons to regenerate, it did identify the ability of undamaged axons to sprout or grow towards a vacant synapse.

Steward (1989) suggests that this earlier work has been followed subsequently by numerous studies that have demonstrated conclusively that there is growth of axons with the development of new synapses following injury (Raisman, 1969; Lund and Lund, 1971; Westrum and Black, 1971; Cotman and Nieto-Sampedro, 1985; Bishop, 1982).

In his book on Traumatic Brain Injury, Bach-y-Rita (1989) describes these earlier years of neuroscience as *'the dark ages'* for rehabilitation neuroscientists as there was little

enthusiasm for the development of knowledge in this field and consequently a lack of interest in the rehabilitation of neurologically damaged patients. Without doubt this was the experience of physiotherapists working in the area of stroke rehabilitation. Perhaps, more frustrated by this lack of interest, as clinical experiences indicated that changes in the CNS were being induced by physiotherapy intervention as approaches moved from compensatory strategies to induced recovery strategies (Carr and Shepherd, 1989; Bobath, 1991).

Since the '*dark ages*' there has been an explosion in the field of neuroscience revealing the capacity for recovery of function and identifying the mechanisms responsible for that recovery (Finger and Stein, 1982; Cotman and Nieto-Sampedro, 1985; Bach-y-Rita, 1980, 1981b,). This has resulted in the development of the concept of neuroplasticity introduced earlier in the literature review where it was relevant to the validity of both models of disablement and the measurement of functional recovery. As suggested, it is a concept that has far-reaching implications for physiotherapists treating the neurologically impaired patient as it may represent the underlying mechanisms by which they seek to rehabilitate motor control. Bach-y-Rita defines this new concept as being:

'the adaptive capacities of the central nervous system, its ability to modify its own structural organisation and function.'

Bach-y-Rita (1980, 1989)

Gispén (1993) in his review of neural plasticity defines neuroplasticity, adding an interesting environmental component suggesting that plasticity is:

'the capacity of the neurone to adapt to a changing internal or external environment, to previous experiences, or to trauma.'

Gispén (1993)

As presented earlier (section 2.4), Bach-y-Rita (1989) has suggested that this adaptive capacity of the CNS can also be maladaptive in response to functional demands. This definition implies that the CNS may change in response to injury in a normal or abnormal way suggesting that the development of spasticity or compensatory mechanisms may be maladaptive neuroplasticity. This concept is of great significance to stroke

physiotherapists using a non compensatory treatment paradigm. Balliet (1989) suggested:

'The only difference between compensatory and non-compensatory functional outcomes may often be one of specific vs non-specific training, respectively.'

Balliet (1989)

He continued by suggesting that the final proof will come from discovering factors that will lead to *'the optimisation of positive adaptive effects and to the minimisation of negative adaptive responses.'*

Acheson-Cooper and Saarinen-Rahikka (1986) suggested, that another concept closely intertwined with the new concept of neuroplasticity, is the concept of *'plateauing'* in the recovery process, where theoretically, the adaptive capacity of the CNS appears to cease. Supporting an earlier presentation of this concept, she continues by agreeing that this long recognised concept is one about which very little is known and much is assumed. Dombovy and Bach-y-Rita (1988) suggested that Twitchell (1951) first described the concept in his study of 121 stroke patients in which 19 were followed until recovery *'plateaued'*, the term being used to indicate no further recovery within the CNS and subsequent discharge. However, it was in fact, suggests Schmidt (1988), a concept first recognised in 1897 by Bryan and Harter. They described a *'plateau'* as being periods of no improvement between other segments of improvement within the area of memory and learning.

Whilst Twitchell's (1951) description became the established concept of a *'plateau'* in rehabilitation terms, Bach-y-Rita and Balliet (1981) discussed the possibility of plateaus occurring *'between phases of acquisition'* suggesting that:

'the acquisition-consolidation alternating sequence may be a general characteristic of progressive development. Thus, the recovery obtained by rehabilitation of the post acute patient may be interpretable in these terms.'

Bach-y-Rita and Balliet (1981)

Further evidence of this pattern of neuroplastic adaption is presented by Shumway-Cook and Woollacott (1995), identifying Gesell's studies on infant development (1946). Gesell noted that postural control develops in a pattern of discontinuous step-like progression with periods of consolidation characterised by fall backs in skills as the child progresses through the motor milestones.

Whilst Acheson-Cooper and Saarinen-Rahikka (1986), Twitchell (1951) and Dombovy and Bach-y-Rita (1988), describe plateaus or consolidation phases as an end point in the recovery process, the only evidence that could be found in the literature of this concept occurring during the recovery process are the earlier suggestion by Bach-y-Rita and Balliet (1981) and the observations made by Gesell (1946). Interestingly, work by Book (1925) and Keller (1958) into the patterns occurring during the learning of Morse code, identified periods of consolidation prior to the acquisition of codes. This concept of '*plateaus*' in recovery will be discussed in the light of new findings from this study.

4.2. Neurophysiological Models of Stroke Rehabilitation: An Historical Perspective

Prior to the development of a neurophysiological model of stroke rehabilitation, the management of neurologically impaired patients revolved around a biomechanical approach that encouraged compensatory strategies. Neuroscience dictated that no neural recovery occurred, therefore during this period patients were encouraged to use the unaffected side of the body to overcome the loss of normal movement on the affected side. Parry (1982) in her review of physiotherapy approaches in stroke rehabilitation uses the term '*traditional physiotherapy*' to describe this concept of taught compensation (Bullock, 1975), suggesting that motor loss was seen to be '*relatively irrevocable*'.

This traditional biomechanical approach, relied on orthopaedic interventions of bracing (Stern and Gorga, 1988) and surgical correction to achieve safe but abnormal function (Ashbum, 1995). Parry suggests, that the main aims of the approach were to address the musculoskeletal system. improving ranges of movement and muscle power with little concern for the neurophysiological requirements of movement recovery. As McGlown (1990) in his chapter on the historical perspective of rehabilitation states in reference to the use of callipers and braces:

'standard orthopaedic procedures place undue emphasis on the palsy to the detriment of the cerebrum.'

McGlown (1990)

One pioneering orthopaedic surgeon of the time, who did have an insight into the neurological needs of the brain damaged patient, was W M Phelps (1952). Working predominantly with cerebral palsy children, Phelps established the first residential rehabilitation centre in Maryland, developing what became the standard orthopaedic physiotherapy techniques for children. McGlown suggests, that whilst Phelps will always be remembered for his braces and callipers, his uses of relaxation, proprioceptive feed back techniques and the implementation of massed movement patterns were the foundation of later work by Rood (1954, 1962), one of the pioneers of the neurophysiological approach to physical rehabilitation.

4.2.1. Neurophysiological Approaches

A further move away from the established orthopaedic approach was instigated by Temple Fay (1954), a neurosurgeon in Philadelphia. Fay and later Doman and Delacato (1960), based their concept of neurological rehabilitation on the theory of recapitulation. This theory suggested that the phylogenic development of the human species was reflected by the ontogenic development of the CNS in man. Fay therefore recommended the use of primitive reptilian movements as a prerequisite of crawling and walking (McGlown, 1990).

This concept of ontogenic development was mirrored in work emerging from two further pioneers in the area of neurophysiological rehabilitation and was known as the Bobath Approach. There was however one fundamental difference between this method and the programming of the Doman and Delacato approach. Whilst the Bobaths (1978) facilitated the earlier ontogenic patterns using automatic responses as a basis for volitional activity, Doman and Delacato passively moved the damaged patient using large numbers of volunteer programmers with apparently little use of cognition or goal direction.

Doman and Delacato took their approach further, suggesting that function is preceded by use and the repetitive stimulation of nerves and muscles was required for long periods of time in order to promote the development of functional abilities. It is interesting that whilst considerable controversy has existed regarding this intensive and extremely well marketed approach (Cummins R A, 1988), there is now sound evidence that the CNS does in fact adapt and change in response to sensory input from the environment (Rosenzweig, Bennett and Diamond, 1972; Rosenzweig, Bennett and Krech, 1965) and to repetition as a foundation for learning (Kottke, 1975) cited in Wilcock (1986). The studies of Rosenzweig et al., (1972,1965) demonstrated that infant and adult rats in an enriched environment had a greater cortical thickness and weight.

However, as identified in chapter 3, in the context of measurement validity and the recovery of function, Bach-y-Rita (1989) has suggested that this adaption to the environment via sensory input could be either adaptive or maladaptive. This concern and a concern regarding the lengthy periods of time families were expected to '*program*' their children in order to promote recovery was clearly identified by a number of authors (Cummins, 1988; Robbins and Glass, 1968). In 1968, a statement was issued by a number of professional bodies in the USA and Canada (McGlown, 1990) condemning the approach as being potentially harmful to the family unit and based on unsound neurophysiological theories.

McGlown however, makes the point that, whilst in no way supporting the practices of Doman and Delacato, some of their ideas are now incorporated into present day therapies and scientific knowledge can now begin to explain how repetition and environmental simulation can have an adaptive affect on the CNS. Doman and Delacato's theories of recapitulation have been superseded by newer theories of neuroplasticity and motor relearning.

During this period of time a number of models of stroke rehabilitation emerged that were based on neurophysiological theories of motor control. Physiotherapists such as Brunnstrom (1970), Rood (1954), Knott and Voss (1968) and Bobath (1963, 1969, 1978), unhappy with the established theories of stroke rehabilitation, began to question the compensatory paradigms of the earlier orthopaedic biomechanical approaches. Having learnt through clinical experiences that the affected side of the body could

recover, they began a move away from compensation towards normal functional recovery.

These approaches, reviewed in the literature (McGlown, 1990; Gillettee, 1969; Levitt, 1977; Bleck, 1987), were based on a number of theories of motor control. One such approach became known as the Bobath Approach and it was based at the time on a reflex and hierarchical theory of motor control.

The approach was developed in the 1960s and 70s by Berta Bobath, the physiotherapist wife of a physician, Karel Bobath. Karel, a positivist, (Parry, personal communications 1996) needing explanations for the qualitative, empirical evidence of neurological recovery observed by Berta during her treatments of neurologically damaged children, sought to explain her treatment results using existing theories within the neurophysiological sciences.

4.2.2. The Evolution of the Bobath Approach

Dr Karel Bobath, a Czechoslovakia-Sudetenland physician, and Berta Bobath, a physiotherapist, were born in Germany in 1906 and 1907 respectively. After arriving in the UK prior to the Second World War they spent the rest of their lives devoted to the development and teaching of a treatment approach that would change the lives of both physiotherapists and neurologically impaired patients.

In his biography of the Bobaths, Schleichkorn describes how the Bobath Approach was apparently '*discovered*' by accident when Berta Bobath was asked to treat a well-known portrait painter, Simon Elwes, who had a stroke:

'Instead of doing what I had been taught, exercises, I observed the patient, slowly by trial and effort, by observation and deduction, I began relating things he was doing in response to what I was doing. It worked better than anything before.'

Berta Bobath quoted in her Biography by Schleichkorn (1992)

They became interested in the treatment of children with cerebral palsy, observing over the next few years both abnormal and normal movements. Berta's empirical observations enabled them to formulate the hypothesis that it was a lack of neural inhibition that resulted in the presentation of abnormal reflexes and abnormal postural tone, concluding that these reflexes must be inhibited before more normal or mature postural reflexes could be facilitated.

Using the best explanations available at that time, Karel used three theories of motor development and control as the basis for their treatment approach, two of which have frequently become linked and known as the reflex-hierarchical theory (Shumway Cook and Woollacott, 1995).

The reflex theory was first documented by a neurophysiologist, Sir Charles Sherrington, who discovered the existence of reflexes in a number of animal experiments (Sherrington, 1947). Sherrington believed that reflexes formed the basis of neural control either as individual units consisting of a receptor, a conductor and an effector or as groups of linked reflexes that produced more complex tasks. (Gallistel, 1980; Shumway Cook and Woollacott, 1995). Whilst Sherrington was aware that reflexes were only one part of the jigsaw of motor control, his contemporaries of the time interpreted this theory as being the singular means of motor control.

Obviously reflex control exists in the CNS however, evidence has emerged that demonstrates that movements can occur in the absence of sensory or receptor stimulation (Taub, 1968). In the 80s Grillner (1981) published his work on cats in which he was able to demonstrate that the spinal neural network of a cat can produce locomotor activity in the absence of either sensory input or descending input from cerebral cortex. This new knowledge has led to the development of a theory of motor control known as the Motor Programme Theory, one of the basic concepts of which being the Central Pattern Generator theory (CPG).

This theory based on Grillner's work and the earlier studies of Wilson (1961) and Forssberg et al., (1975) have resulted in the development of a concept of locally organised neural circuitry in the spinal cord that can generate quite complex activities independently. Forssberg's work suggested that these CPGs could be modulated by

sensory input and this has become one of the present theories underpinning the present Bobath concept. Unfortunately this updating of the theoretical basis of the approach has not been documented in the literature, as Lennon suggests (1996) updating occurs '*via an oral tradition on postgraduate course*'.

The second theory on which the Bobaths based their treatment approach was that originally identified by Hughlings Jackson in which the CNS was organised into higher, middle and lower levels of motor control. This became a fundamental issue in developing the Bobath Approach (Semans, 1967) as they linked Sherrington's reflex theory with the hierarchical control theory suggesting that the loss of higher level control leads to '*abnormal postural reflex activity*' (Bobath, 1965).

Using their empirical observations of children, together with work by Schalterbrand (1928) in which he described child development in terms of the appearance and disappearance of reflexes, they developed the original treatment principles of inhibiting abnormal reflex activity and facilitation of normal developmental sequences.

The final theory that was used to explain the clinical findings observed by the Bobaths was Magnus' theory of shunting which stated that:

'the different attitudes with their different distribution of tone and tension in the numerous muscles of the body, are associated with different distribution of reflex irritability over the central nervous system. Therefore one and the same stimulus may cause quite different reflex reactions according to the different attitudes of the animal at the moment the stimulus is applied.'

Magnus (1926) cited in Kidd et al., (1992)

The Bobaths used this theory to explain why the movement of patients' limbs altered tone in the limb (1963), suggesting that different pathways were being opened at the spinal cord level. Kidd et al., (1992) suggest that these earlier assumptions about the theory of motor control have been supported by the studies of Forssberg et al., (1975) and Grillner and Rossignol (1978) in which cats injected with clonidine were used to demonstrate the effects of limb placing on reflex activity in the contralateral limb and later by Rossignol

and Gautier (1980). Kidd et al., (1992) also suggested that the original concepts of neural gateways has now been supported by evidence of the involvement of descending tracts and afferent input onto spinal interneurons having the potential for opening and closing neural pathways .

The original observations of a change in position producing a change in limb tone, resulted in the development of the '*reflex inhibiting postures*', used as a technique to inhibit abnormal postural tone and facilitate normal postural tone. These techniques have been supported by Grillner's work (1981) in which he identified the influence of proximal limb positioning on spinal cord output in animal studies on the neural control of locomotion.

A further assumption on which inhibition and facilitation treatment models was based, related to the weight bearing through normally aligned joints (Bobath, 1971). This earlier assumption has again been supported by subsequent work on alignment and limb loading in gait studies (Herman et al., 1973; Cook and Cozzens, 1976; Millar and Musa, 1982).

McGlown (1989), who supports the hierarchical reflex theory, suggests that the Bobaths lost direction in the 1970s and 1980s. However, it was perhaps more likely that they were developing their concept as a result of clinical observations and that these changes have now been supported by new knowledge within the field of neuroscience. It would appear from the literature however, that these changes in treatment strategies implemented and taught at post graduate level have not been published or evaluated. This lack of publications has resulted in considerable criticism within the current literature (Ostrosky, 1990; Mathiowetz and Haugen, 1994).

Whilst the Bobath Approach appeared, during the late 70s and 80s, to have adapted treatment principles in response to evidence provided within the area of neurophysiology there is no evidence that they were at this time responding to the studies on motor behaviour and cognition. In a recent review of the theoretical assumptions underlying the Bobath Approach, Lennon (1996) presents an up-to-date outline of the approach as it is taught today. She suggests however, that the Bobath Approach does not '*integrate principles of motor learning into its framework*'.

4.2.3. The Current State of the Art

If the Bobath concept has moved forwards as a result of clinical observations and emerging neurophysiological knowledge, it is still unclear as to whether the present day approach has incorporated the evolving science of motor control and motor learning.

What is clear is that during the late 1980s the Bobaths began to move away from the more rigid hierarchical reflex theories using treatment models that incorporated new strategies. Again this change evolved as a result of clinical observations as Stem and Gorga (1988) described the two fundamental principles of the management of the brain damaged child using a Bobath Approach:

'it became clear that the chief difficulty for the handicapped child was to receive and integrate environmental information and to co-ordinate the response to allow him or her to interact with the environment..... it was important to take into consideration the vital relationship between movement and beaming.'

Stem and Gorga (1988)

The notion evolved that normal movement was the key to learning and movement itself provided the sensory input that could modify the CPGs (Forssberg et al., 1975). Partridge et al., (1993) identified this change in the Bobath Approach when they suggested that treatment models had become more functionally directed. Whilst Partridge incorrectly suggests, that treatment models are no longer aiming at inhibiting abnormal tone (Bobath, 1991), she does continue by claiming that facilitation is aimed at the relearning of normal movement. Similarly, Bohman (1987) in describing the use of the Bobath Approach for the management of elderly stroke patients suggests that abnormal tone must be inhibited in order to facilitate normal movement. Bohman clearly stating that functional activities were the outcome of this process of normalisation of postural tone.

Sadly, the final third edition of the Bobath's book (1991) which documents the '*continuation and further development of treatment*' simply reiterates the original neurophysiological theories identified by Karel Bobath at the inception of the approach.

Continuing the previous statement describing this edition they write '*the underlying concept on which it is based has not changed*'. The book then continues by describing under a heading of '*Neurophysiological Considerations*' the reflex and hierarchical theories of motor control.

Because of this lack of evidence in the published works of the Bobaths that they had integrated knowledge from the fields of motor control, motor behaviour or motor learning within their treatment approaches, evidence must be sought in the publications of physiotherapists who base their treatment approaches on the original concepts identified by the Bobaths.

One such physiotherapist, whose work has been of significant importance in developing a treatment model based on the rehabilitation of selective trunk movement over the past decade, has been Davies (1985, 1990, 1995). Davies, an experienced physiotherapist and educator, learnt from the Bobaths and Suzanne Lein Vogelbach. Using her clinical knowledge and experience she identified the importance of selective trunk activity in the rehabilitation of stroke patients. Davies (1990) states that she learnt from the Bobaths the importance of trunk movements, particularly rotation as a mechanism for reducing hypertonia, using this proximally to inhibition distally. Appropriate alignment of the trunk opening correct pathways in the CNS and therefore reducing postural tonus in the limbs, Kidd et al., (1992) suggested that this process might be based on work on Central Pattern Generators (Grillner, 1975; Mulder, 1991).

Davies continued her education as a neurophysiotherapist working closely with Joan Mohr, an American therapist teaching the Bobath concept at the Bad Ragaz centre in Switzerland. Davies states that Mohr's greatest contribution to her knowledge was her description of the development of trunk activities in normal babies (Mohr, 1984; 1985; 1987). This concept of selective trunk control and the development of selective trunk activity will be discussed in the light of the results from this study.

It would appear from the literature, however, that there is little documented evidence of research into this important and developing model of practice. Davies (1990) states that during a computer search for research on stroke and trunk or abdominal activity no papers were identified. Whilst a number of studies have looked at upper and lower limb

contributions to functional skills (Sjostrom et al., 1980; Watkins et al., 1984; Smutok et al., 1989) few studies exist that look at muscle activity in the trunk, even though trunk activity must be the basis for all functional skills (Charlton, 1994). Davies states that work done by Badke and Duncan (1983) on motor responses during postural adjustments when standing examined only muscle activity at the hip, knee and ankle.

The importance of trunk control in the achievement of motor tasks has been supported by Charlton (1994) in her editorial on motor control issues. Charlton further suggested that the way forward in the understanding of motor control may be *'to study actions and not discrete movements'*.

Some research literature does in fact exist where authors have endeavoured to provide evidence of the relationship between trunk strength and function (Bohannon, 1992, 1993, Bohannon et al., 1995; Millington et al., 1992; Woodhall-McNeal, 1986). However, the method of strength testing in totally inappropriate movement patterns (Bohannon et al., 1995), demonstrates a lack of understanding of both the nature of tonal deficits in stroke patients and the role of the trunk and pelvis in the recovery of function following stroke. This biomechanical literature would seem to be in conflict with the clinical practice of Bobath physiotherapists and will be discussed in depth in the light of the research findings from this study. No studies could be found that investigated the use of selective trunk activities advocated by therapists such as Bohman (1987), Davies (1990) or Mohr (1990).

Whilst Davies (1990) identifies the importance of selective trunk activity and the need to normalise tone, she does not include any references to motor learning as a mechanism for implementing treatment or facilitating recovery. In her latest book (1995), however, she clearly identifies this concept in the management of the head injured patient. Citing Affolter and Stricker (1980) *'acquisition, teaming, development, these processes appear to evolve as a result of continuous interaction between environment and the individual'*, she makes the case that the CNS learns through *'doing'*, using the concepts of *'perceptual and motor schema'* previously reviewed.

Furthermore, Davies continues by highlighting the importance of repetition and goal planning in the rehabilitation process. In an attempt at distancing herself from the original concepts of neurological rehabilitation Davies states:

'If all the above factors related to learning are taken into consideration and regarded as criteria, it is clear that no therapy based on reflex responses can help the brain damaged patient to learn or relearn to function adequately and independently, because non of the criteria for learning are fulfilled.'

Davies (1995)

Whilst this book is predominantly about the rehabilitation of the brain injured patient, inevitably such concepts can be transferred into the treatment ideas for patients with unilateral brain damage caused by a CVA.

This was the only evidence found in the literature to support the argument that the Bobath Approach had moved away from the original concepts of reflex/hierarchical motor control to incorporate the motor behavioural theories of motor control and learning. Whilst Davies' work has evolved from the Bobath Approach there is no evidence in the literature that this changing perspective is that of the Bobath protagonists in the UK. Indeed certain authors (Carr et al., 1994) would suggest that Davies is, in fact, not Bobath. In their study of therapeutic practices used in Australia they clearly differentiate between therapists using Bobath principles and those using Davies' principles.

Berta Bobath clearly identifies in her book the evolution in the model of treatment stating that:

'We have discarded all static ways of treatment like reflex-inhibition postures, but have introduced a strong emphasis on movement and on functional activities.'

Bobath (1990)

However, the theoretical basis of the book relies heavily on the original theoretical basis that she and Karel identified in the early 60s. This lack of up-to-date documentation of the changes in the theoretical basis of the approach identified by a number of authors (Ashbum, 1995; Carr and Shepherd, 1989; Shumway Cook and Woollacott, 1995; Keshner, 1981; Wagenaar et al., 1988; McGlown, 1989; Guarna et al., 1988; Lennon, 1996) has resulted in a lack of support for the present Bobath treatment approach in the literature (Wade, 1992a; Tallis 1989). In his article in the Lancet, Wade states: *'what little information there is appears pragmatic, functional (behavioural) approach, adherence to unscientific theories (e.g. Bobath) is to be avoided.'* Whilst the approach is practised throughout the world, published evidence of the present theoretical basis is limited or non-existent.

4.3. Summary

A number of issues have been identified in this review of neuroscience and physiotherapy approaches based on a neurophysiological model:

- Some evidence within the area of neuroscience has emerged in support of clinical practice used by Bobath physiotherapists.
- There has been a move towards the use of selective trunk activity as a basis for functional activities. However it is difficult to establish from the literature whether it has been integrated into the Bobath Approach.
- Whilst there is some limited evidence that the Bobath Approach has incorporated some aspects of motor learning within its treatment paradigms this change is not reflected in external perceptions of the approach.
- The scarcity of up-to-date publication of the theoretical basis of the Bobath Approach has resulted in a misinterpretation of the current state of the approach and in a lack of evaluation of the effectiveness of the approach.

5. THE BEHAVIOURAL AND COGNITIVE SCIENCES: AN HISTORICAL PERSPECTIVE

The evolution of the study of neurophysiology as a basis for both movement and recovery, identified earlier, was being mirrored during the pre- and post-War era by similar developments in the study of motor behaviour (Schmidt, 1988). This earlier work had developed from the field of psychology and involved the study of skill performance (McCloy, 1934, 1937). It was subsequently followed post-war by a move towards procedures for learning, skill retention, transfer of activities (Adams and Reynolds, 1954; Stelmach, 1969) and the study of effort (Kahneman, 1973), concentration, speed and accuracy of movement (Fleishman and Rich, 1963).

Schmidt, in his historical review of the behavioural sciences, suggests that early research on the neural control of movement tended to study individual neuromuscular units frequently using nerves and muscles isolated from the CNS by '*experimentally induced spinal cord damage*', without consideration of the movement pattern or mechanism of execution. He continues by stating that the motor behaviour studies involved complex actions such as typing: '*With very little concern about the underlying neural or biomechanical mechanisms that controlled them.*' (Schmidt, 1988). This development of research within the area of motor behaviour paralleled the work in neurosciences on neuroplasticity. However, the two disciplines lacked, at this time, any collaboration or cross fertilisation of ideas.

During the 70s motor behaviour studies were influenced by the work of Neisser (1967) in the area of cognitive information processing. This move towards cognitive psychology was, suggests Schmidt, in response to the over simplification of stimulation response theories (Hicks, 1952), replacing them with ideas about the underlying mental and neural processes that allow movements to be learnt and reproduced. Rosenbaum (1991) in his book on Human Motor Control, states that during this period research on mental practice became a popular topic, citing numerous studies that investigated the value of mental versus physical practice (Feltz and Landers, 1983; McBride and Rothstein, 1979).

These studies concluding that, whilst mental practice did improve skill learning, it was less effective in doing so than physical practice.

Much of the work at this time was based on Fitts' Stage Theory (1964) which suggested that there were three stages of skill acquisition. The first stage was a '*cognitive*' stage during which verbal cues may be required and, suggests Rosenbaum, a considerable level of attention. The second '*associative*' stage was a transfer of reliance from verbal to more automatic control, this Fitts felt was a process highly reliant on knowledge of success or failure. Johnson (1984) in his subsequent work on the feedback required for skilled learning demonstrated this was an essential component of this phase. Fitts' final automatic stage suggested that the skill could be performed quickly and consistently with little conscious involvement.

Rosenbaum (1991) describes two further concepts associated with memory, '*procedural*' and '*declarative*' knowledge (Squire, 1987). Procedural learning has significant relevance to the memory and learning of motor skills, as it relates to the ability to learn components of a performance.

Much of this work on cognition has significant implications for the relearning of motor task. However, little evidence of its occurrence in the rehabilitation of stroke patients could be found in the literature. Fitts' theory of skill learning will be discussed in the light of evidence provided by this study.

Schmidt suggests these developments, in the field of cognitive information-processing, resulted in a transition in the field of motor behaviour from a '*task orientation*', where studies had concentrated on the effects of variables on the performance of motor tasks, to a '*process orientation*', where studies became focused on the underlying mental and neural activities that enabled the development and, theoretically, the redevelopment of movement (Pew, 1970; 1974).

This concept of process orientation resulted in the development of theories of short (Posner and Konick 1966) and long term motor memory (Loftus and Loftus, 1980), motor learning (Adams, 1981) and Schmidt's own schema theory for motor learning (1975). Schmidt's theory took the concept of schema, an abstract representation stored

in the memory (Shumway-Cook and Woollacott, 1995) and applied it to the area of motor control in the form of stored motor programs. The suggestion by Schmidt was that practising a skill would produce the most effective motor schema or program.

Schmidt's theory has some support in the research literature particularly in studies in children (Kerr and Booth, 1977) where they were trained to throw bean bags over variable distances and demonstrated that practice increased skill level. Results of studies on adults, however, are conflicting (Shumway-Cook and Woollacott, 1995).

Prior to the 70s the neurophysiologists and behavioural scientist had in Schmidt's words been '*oblivious*' to each other. This had not, however, been the case in Eastern Europe where a Russian scientist, Bernstein and his colleagues, had begun to integrate the behavioural, neurophysiological, neuromuscular and biomechanical data in their studies on gait (Schmidt, 1988). It was not, however, until the late 60s that translations of this work became available in America and England (Schmidt, 1988; Brooks, 1986).

This concept of incorporating the different sciences involved in the study of movement was introduced to the Western World in the mid 60s (Brook, 1986) and was subsequently followed in the 70s by the first cross fertilisation and testing of ideas (Schmidt, 1988). The main concentration of this work was an attempt to find association and links between motor behaviours and neural mechanisms (Grillner et al., 1972; 1975; and Bowen, 1980).

Schmidt's presentation of the history of the merging disciplines predominantly revolves around the behavioural and cognitive studies. Whilst he introduced the reader to the earlier studies in the area of neuroscience, he fails to describe the later developments that have resulted in the linking of the two areas to form a new field of studies, known as movement control and learning.

The emergence of scientific evidence of recovery within the CNS by the neuroscientists (Finger and Stein, 1982; Cotman and Nieto-Sampedro, 1985; Bach-y-Rita 1980; Back-y-Rita and Balliet, 1981) and links between recovery and relearning (Kandel, 1989) are not included in either Schmidt's or Rosenbaum's work. In a similar way, neither author

present any evidence of the neurophysiological mechanisms of short and long term memory or the location of memory within the CNS.

This information is essential in the rehabilitation of stroke patients as the site of the lesion may not only effect the ability to relearn motor skills, but also, it may dictate the process by which the therapist might attempt to facilitate recovery. The relationship therefore, between the previously fragmented areas of neurophysiology and motor behaviour is extremely important if the theoretical basis of stroke rehabilitation is to be identified.

5.1. A Motor Learning Model of Stroke Rehabilitation

One stroke rehabilitation approach that has evolved in response to this emerging knowledge from the areas of behavioural and cognitive sciences, is that developed by Carr and Shepherd and known as the Motor Relearning Programme (1982, 1987). Whilst acknowledging the influences of the Bobaths to their earlier practises, Carr and Shepherd suggest that the neurophysiologically based approaches such as those developed by Bobath, Knott, Voss, Brunnstrom and Rood in the 60s and 70s failed to respond in the 1980s to the emerging knowledge in the area of motor learning (1987). They suggest that rather than relying on the empirical evidence of traditional '*exercise or facilitation therapy*' and out dated scientific knowledge (Carr and Shepherd, 1987), the role of the physiotherapist in stroke rehabilitation lies in:

'the training of motor control based on an understanding of the kinematics and kinetics of normal movement, motor control processes and motor learning.'

Carr and Shepherd (1987)

It would appear from the literature that during the 1980s Carr and Shepherd, whose origins lay within the areas of neurophysiologically based therapy had moved towards a behavioural and biomechanical approach to stroke rehabilitation.

In 1989 they published a paper clearly identifying the importance of movement analysis introducing the concept of body segment alignment as a basis for normal movement. Using a biomechanical model they suggested that work by Bernstein (1967) Kelso and

Tuller (1984) and Gentile (1987) supported the idea that segmental alignment and postural adjustments were specific to the action or task to be performed. This led them to suggest that practise of one component of a movement will not necessarily improve the patient's ability to perform another '*biomechanically different action*' (1989).

It can be seen how the two approaches had, by the late 1980s, very different views about the recovery of motor skills. On the one hand the Bobath Approach incorporating Davies' work on selective trunk activities used the facilitation of these components as a foundation for numerous functional skills; on the other Carr and Shepherd were advocating the training of specific tasks '*utilising the biomechanical characteristics of each task*' (1989), with little apparent emphasis on trunk activity but rather on more highly specialised upper and lower limb control. It is here perhaps that the fundamental difference between the two approaches lay. Bobath remaining faithful to the normalisation of postural tone using the normal automatic postural reactions as a process for rehabilitating normal movement and Carr and Shepherd utilising the cognitive biofeedback processes to achieve normal movement (1994).

In summary, it might be suggested that the two differ not only in the theoretical basis used, Bobath being predominantly neurophysiological and Carr and Shepherd being biomechanical and behavioural, but that they also differ in the process of remediation. Bobath relying heavily on the facilitation of automatic reactions through selective trunk activities and Carr and Shepherd using volitional activities with biofeedback.

It is difficult to establish whether Carr and Shepherd in moving towards a cognitive, biomechanical approach lost sight of the tonal consequences of the original neurological damage. By 1994 they were frequently using the term '*muscle strength*' (1994) using kinematic analysis of movements such as sit-to-stand to develop '*a normal model of sit to stand as a guide to evaluation and training of this action in the clinic*'. The purpose of this review is to establish the fundamental similarities and difference between the various approaches to stroke rehabilitation, the biomechanical analysis of movements and the subsequent use of this analysis to develop training programmes, with an emphasis on muscle strength rather than tone, will be discussed subsequently in the light of findings of this study.

A further area of significant importance to the theoretical models of rehabilitation is that of recovery versus compensation discussed in relation to the models of disablement (section 2.1). Carr and Shepherd clearly state the importance of goal attainment using non-compensatory strategies (1989), suggesting that early intervention may prevent the development of compensatory movements limiting the potential for recovery of '*more effective movements*'. They suggest that the physiotherapist guides the patient using motor training to overcome compensatory mechanisms. In this way both approaches are similar. The Bobaths advocate the normalisation of tone to inhibit the patient's use of abnormal tone to achieve the functional goal (Bohman,1987; Lynch and Grisogono, 1991).

Lynch and Grisogono suggest that the use of cognition and volition may limit the application of the Motor Relearning Programme as it requires the patient to be '*fully aware of what they are doing*', (1991) excluding patients with severe perceptual and cognitive deficits. Reading et al., (1993) found that 71 % of patients admitted for stroke rehabilitation had behavioural and cognitive impairments and Tatemichi (1994) found cognitive impairments in 35.2% of stroke survivors. Jeffery and Good (1995) suggest that cognitive function is an important determinant of outcome. However its importance, perhaps, lies in the choice of rehabilitation methods.

This interesting suggestion of patient exclusion is supported by Mathiowetz and Bass Haugen (1994) who state that the reliance on cognition during the implementation of the motor relearning programme '*makes it difficult to use with clients having cognitive impairments*'. A further interesting point made by Mathiowetz and Bass Haugen relates to the concept of motor learning utilised in both the neurophysiological approach of the Bobaths and the Motor Relearning Programme of Carr and Shepherd. Mathiowetz and Bass Haugen suggest that '*the performance changes that occur during practise are only temporary and thus do not reflect learning*'. Using Schmidt's (1988) definition of learning as requiring the outcome to be a '*permanent change in the capabilities of responding*' Mathiowetz suggest that neither of the two rehabilitation approaches result in the transfer of skills and that temporary achievement or '*acquisition*' is lost after intervention. This suggestion will be discussed in the light of the results of this study.

As with the Bobath Approach, there is little evidence in the literature of the effectiveness of the Motor Relearning Programme. Only one study, published by Dean and Mackay (1992), could be found in the literature. In this retrospective study, 70 stroke patients undergoing intensive treatment based on the motor learning model of rehabilitation were evaluated using the Motor Assessment Scale (MAS) developed by Carr and Shepherd (1985) as measure of outcome with stroke patients. The patients were scored at admission and discharge with fortnightly scores during treatment.

Whilst Carr and Shepherd assessed the reliability of the measure suggesting an average interrater correlation of .95 and an average test retest correlation of .98, they do not present the developmental process of the measure. It is therefore difficult to establish the face validity of the scale although Poole and Whitney (1988), reportedly, assessed the concurrent validity of the measure, finding it an acceptable measure of the motor Relearning approach.

The results of the study by Dean and Mackay suggested an improvement in all of the items scored by the MAS, with no patients apparently deteriorating during the recovery phase. Interestingly, the authors of this study noted a *'polarisation of scores for item 8 (the advanced hand activities) with 82% of subjects scoring either zero or six on discharge.'* They found that a number of patients could not achieve scores of 3 or 4 but could achieve a score of 6 bringing into question the validity of the advanced hand activities item to record the patients' functional recovery.

Following a further review of this study, there is also concern regarding the item of *'Balanced Sitting'* in which 65 patients were scored at admission and discharge. It would appear that a large number of the admitted patients could already achieve this item, with 14 of the patients improved from a starting score of 5 to a discharge score of 6, and 6 patients staying at 5. Furthermore 19 patients had on admission and discharge a score of 6. In other words 39 of the patients had either the top or second to top score. As these scores represent high levels of sitting ability and trunk control either the patients were very able in the first place or the item used does not truly represent the ability to recovery balanced sitting following a stroke. A number of the other items scored on the MAS such as supine-to-sitting and sit-to-stand also appeared to cluster at the 6 score

with little or no change from admission, suggesting an unusual distribution of functional ability with a predominance of upper limb deficits alone.

Whilst it is surprising that none of the patients deteriorated during the recovery process, this lack of deterioration may be due to the time periods, fortnightly, for data collection as much can occur in a patient's functional state during a 14 day period. This lack of evidence of deterioration during the implementation of intervention is in conflict with the results of the present study into the recovery of function during the implementation of the Bobath Approach and will be discussed further as it is highly relevant to the concept of motor learning as a theoretical basis for stroke rehabilitation.

Whilst the study by Dean and Mackay appeared to demonstrate no deterioration during intervention, it fails to provide evidence of attribution. It is difficult to establish whether the improvements observed were the results of intervention or would have occurred in the absence of intervention. It will be noted that the time between CVA and commencement of rehabilitation was on average 40.6 days with a standard deviation of +/- 92.4 days. This excessive range does not allow the reader to conclude whether they were early or late patients, again preventing any agreement on recovery being spontaneous, as discussed earlier, or induced by therapy. It is also interesting to note that whilst the researchers mentioned co-existing problems as being amputation and communication difficulties, they did not list cognitive deficit, suggesting these patients were not included in the study.

It can be seen therefore that, as with the Bobath Approach, there is inconclusive evidence of the effectiveness of the approach. The author is aware that a study is to be undertaken in Nottingham at the Stroke Research Centre comparing the Bobath Approach with the Motor Relearning approach. However, only one junior physiotherapist with little post graduate Bobath training is to be compared with a Carr and Shepherd-trained physiotherapist from Australia. This might suggest that it is the skill of the therapist under investigation rather than the treatment model itself. The study which is highly flawed in a number of further areas will be of little value in providing sound evidence of effective interventions be it Bobath, or Carr and Shepherd.

5.2. Summary

Following this presentation of developments in behavioural science and the review of a rehabilitation approach based on this science, there are a number of areas to be highlighted as important to this study:

- The Motor Relearning Programme originated in the neurophysiological therapies.
- In response to new knowledge in the area of motor learning, cognition and movement science, the Motor Relearning Programme has moved towards a behavioural, biomechanical basis for rehabilitation interventions.
- There are some similarities between the Bobath Approach and the Motor Relearning Programme as both are theoretically attempting to rehabilitate normal recovery and prevent the development of compensatory strategies. There is some evidence to suggest that the Bobath Approach uses a motor learning concept as does the MRP; however, the evidence is limited to anecdotal comments in certain publications.
- Whilst the approaches may be similar in the aspects mentioned above, the processes differ. The Bobath Approach uses automatic lighting reactions and tone normalisation prior to the facilitation of volitional activity. The approach relies on the analysis of the components of movement required during the development of motor control in the baby to establish clinical models of selective trunk and limb activity. Carr and Shepherd uses cognitive, muscle strengthening and biofeedback process based on biomechanical analysis to develop clinical models of segmental alignment with specific attention to hip, knee and ankle activity.
- There is little conclusive evidence of the effectiveness of either model for the treatment of stroke patients, although the treatment process and theoretical basis is clearly identified by Carr and Shepherd. The Bobath Approach is poorly

documented with little evidence in the literature of the integration of both motor learning or selective trunk activity developed by Davies or the use of new scientific knowledge in the areas of neuroscience and behaviour.

- This lack of publications has resulted, not only in a misunderstanding of the theoretical basis of the Bobath Approach, but also the development of antagonisms between the two approaches that has limited appropriate evaluation and the development of stroke rehabilitation internationally.

CHAPTER 6

6.1 The Problem

From the literature review it can be seen that a number of problems exist for physiotherapists involved in the rehabilitation of stroke patients. In this chapter these problems will be summarised to determine how they can be addressed during the study, see figure 5. Following this the aims and objectives for the study will be outlined.

6.1.1. The Burden of Stroke and Health Service Reforms

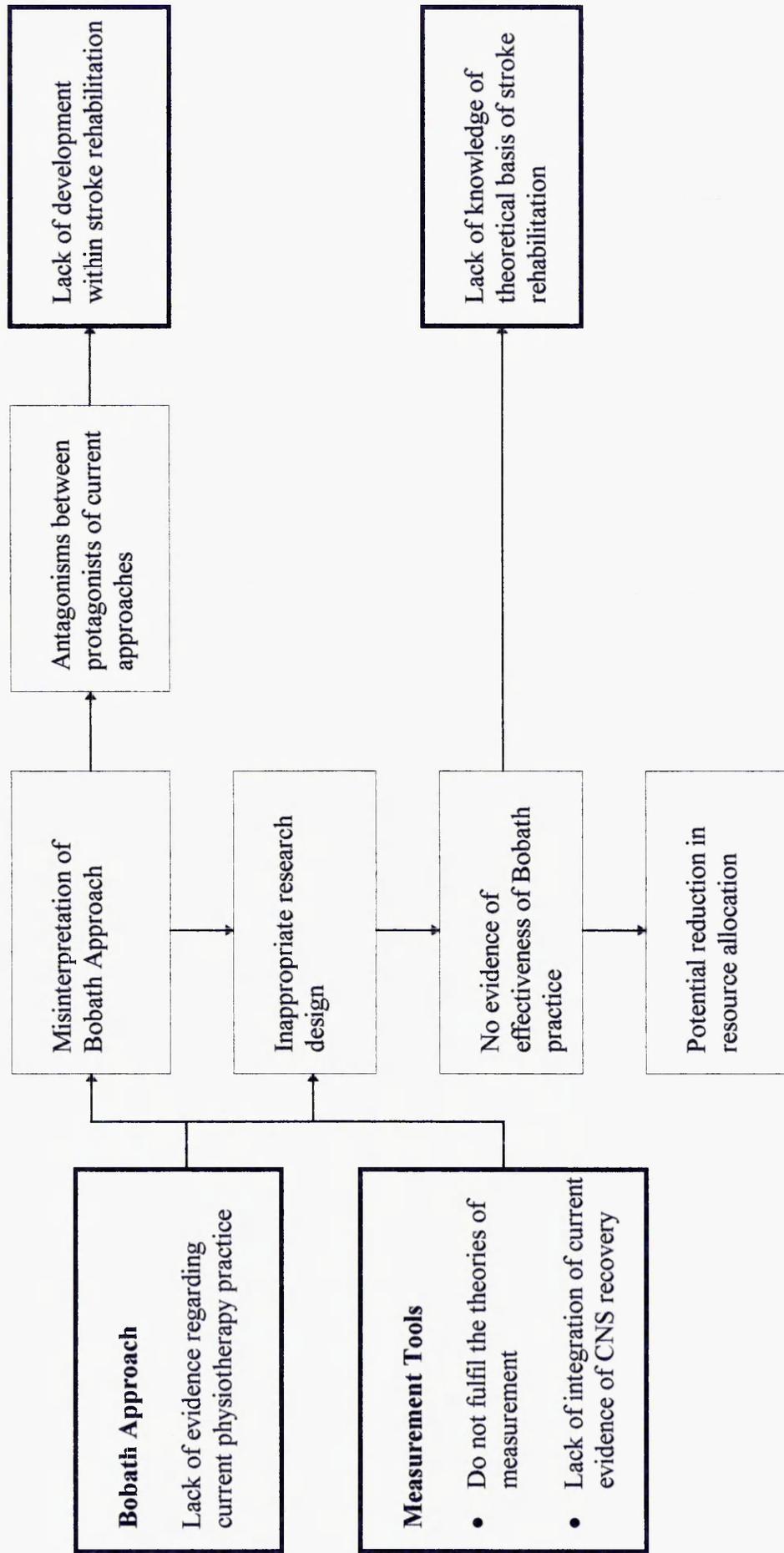
Stroke is both a devastating disease for patients themselves and for their carers and the rehabilitation of residual disability resulting from the stroke is costly in terms of health service resources. If the figures previously reviewed are accepted in 1996 there will be 109,537 first ever stroke victims of which 50% will be left with a significant level of disability. In an average Health District of a quarter of a million, there will be at least 750 people with disabilities attributed to stroke with an estimated expenditure on stroke of £3 million pounds annually.

Whilst medical input is an essential component in the acute phase of stroke management inevitably the overall burden of rehabilitation fails predominantly on the professions allied to medicine. Recent changes in the National Health Service, to accommodate a move towards a competitive, market place philosophy, have resulted in an urgent need for physiotherapists to measure the outcome of interventions quantitatively. With the advent of purchaser-provider contracts, resources have inevitably become linked to evidence of effective practice.

Whilst certain outcomes of physiotherapy, such as changes in stride length, range of movement and vital capacity, may lend themselves to direct, therefore quantitative measures, others do not. The emphasis in the Bobath Approach to physiotherapy has always been on a non-prescriptive, patient specific, holistic, treatment evaluation approach that theoretically produces an improvement in the quality of muscle tone, resulting in an improvement in the quality of movement. The problem being that neither lends itself to direct measurement.

Figure 5

Problems Identified in the Literature Review and to be Addressed by the Study



6.1.2 Measurement of Health Outcomes

During the literature review it became apparent that there is a discrepancy between the established concept of health outcomes and the needs of the physiotherapist in clinical practice. Health outcomes are defined as being a measure of the efficacy of a specific treatment in a controlled environment with identified patients. This definition and subsequent method of collecting data may indeed eliminate the variables attributing to the outcome. Stroke physiotherapists modify treatments by manipulating the internal and external environment perceived by the CNS, the outcome being the ability to move within a variety of settings relevant to the individual patient. Physiotherapists require, therefore, a measure of the effectiveness of input in a clinical setting recording clinically significant changes in '*typical patients*'.

Many of the measures used in health care do not fulfil the theories on which all measurements should be based, this again produced problems for health professionals. Measures purporting to be ordinal scales may not fulfil the requirements established, the averaging of measurement scores eliminating the ability to identify individual patients' needs.

It also became apparent that many measures were based on a concept of compensation, failing to record the recovery of normal function which is the fundamental goal of both the Motor Relearning Approach and the Bobath Approach. These problems of health outcome measurement have themselves led to problems in the provision of evidence on which to base, not only resource allocation, but also evidence on which to base effective clinical practice.

6.1.3 Lack of Evidence of Effectiveness of Treatment Approaches

From the literature it can be seen that there is some evidence of the value of multidisciplinary stroke units. There is little evidence however of the effectiveness of specific physiotherapy approaches to stroke rehabilitation. Whilst in the UK, there are a number of approaches to stroke rehabilitation, the most commonly taught and used approach is that developed by Dr and Mrs K Bobath and known both nationally and internationally as the Bobath Approach. The major problem for physiotherapists using

this approach is a lack of information regarding the outcome of treatment when used to rehabilitate stroke patients. This problem, in part, may be the result of methodological difficulties in stroke rehabilitation research.

The nature of stroke as a disease and the systems which it effects result in a variety of pathological categories each with their own clinical presentations or levels of impairment. This introduces a large number of potential variables to be evaluated in any outcome research plus an added problem of requiring to measure, not only the variability of initial impairment, but also, the resulting level of disability and handicap.

Existing models of disablement on which measuring tools are based may not fulfil the conceptual framework of the Bobath Approach, therefore, measures recommended for use in outcome research may be unsuitable and fail to provide appropriate information. All measuring tools should be based on clinical knowledge however, a clear lack of knowledge regarding the theoretical basis of the Bobath Approach has resulted in a lack of consensus on the most appropriate measure to be used in an evaluation of therapeutic outcomes.

6.1.4 Lack of Information Regarding the Evolution of the Theoretical Basis of the Bobath Approach

The Bobath Approach has evolved over the past decade with the development of both clinical knowledge and scientific evidence of both motor control theories and theories of neuroplasticity. The original reflex and hierarchical theories of motor control on which the Bobaths based their approach has been developed in clinical practice. However, there is little evidence of either this move in the literature or evaluation of proposed treatment models such as the use of selective trunk activity which have become the central components of Bobath inhibition and facilitation techniques taught at undergraduate and postgraduate level.

This lack of information regarding the present process of Bobath rehabilitation in either scholarly or research literature has resulted in a number of problems for stroke physiotherapists. Firstly, it has resulted in the implementation of inappropriate research programmes using outdated treatment strategies that do not reflect current clinical

practise. Secondly, inaccurate critical reviews of the approach in the literature has resulted in the development of antagonisms between followers of different therapy paradigms. This misinterpretation and conflict is potentially limiting the process of scientific development within stroke rehabilitation.

6.1.5 Lack of Clinical Evidence of the Recovery Process Induced During Stroke Rehabilitation

From the literature review it can be seen that there are a number of theoretical models of CNS reorganisation, regeneration and relearning, many of which are highly relevant to the rehabilitation team. The mechanisms underlying both short and long term changes within the neural structures have been proven to exist in a variety of animal studies in response to internal and external environmental stimuli.

The problem for stroke physiotherapists lies in the fact that the concepts of neural adaptation have not been recorded or demonstrated in clinical practice. The links have not yet been established between these theoretical models and clinical outcomes. There may be a number of reasons for this lack of clinical evidence. Firstly, few studies have clearly identified the evolving Bobath treatment model to be evaluated. Secondly, studies have failed to select a measuring tool that fulfilled the conceptual framework of the treatment model to be evaluated and thirdly, few studies have used an appropriate measure to investigate the characteristics of the induced recovery process to establish whether there is evidence of neural adaptation taking place.

It can be seen from Figure 5 that the problems identified in the literature review are inevitably interlinked, however, it can be seen that the origin of the problem lies in two fundamental areas. Firstly, a lack of evidence regarding the current state of Bobath practise. Secondly, a failure of existing measuring tools to fulfil the theories of measuring scales or to recognise and integrate current knowledge of recovery processes within the CNS. Both factors have resulted in, not only a lack of knowledge, but also, a lack of development within the area of stroke rehabilitation in the UK.

6.2 The Purpose of the Study

The purpose of this study will, therefore, be to provide new knowledge about the recovery of motor control during the implementation of the Bobath treatment approach for stroke patients, thereby enabling the development of a theoretical basis for treatment induced recovery.

6.3 The Aims of the Study

- To investigate the physiotherapy process during the implementation of the Bobath Approach for the treatment of stroke patients.
- To investigate the characteristics of the recovery of motor control during the implementation of the Bobath Approach for the treatment of stroke patients.
- To develop a theory of recovery during the implementation of the Bobath Approach to the treatment of stroke patients.

In order to achieve these aims the study was divided into four distinct phases each phase providing information that would enable the study to fulfil the purpose identified. During the research process a combination of qualitative and quantitative methodologies were used, the data frequently termed '*original observations*' being collected in the final phase IV. During the validation phase II and the collection of original data in phase IV the author visited the stroke unit at the Royal Hallamshire hospital three times a week for eighteen months scoring patients on the TELER indicators and the Motor Assessment Scale. Figure 5a identifies the research process and the relationship between this and the collection of '*original observations*'.

Figure 5a **Research Plan Involving Collection of Original Observations.**

Phase	Objective to be fulfilled	Researchers Involvement	Patients	Physiotherapists
Phase I	To identify the specifications for a measure of physiotherapy outcome in Stroke rehabilitation.	Observational fieldwork and semi structure interviews carried out by author at the Northern general Hospital Sheffield.		1 senior 1 superintendent
Phase II	To development and validate a series of TELER Normal Movement Indicators	Delphi technique and consensus meeting involving 5 regional stroke units co-ordinated and documented by author. This process involved the BBTA.	41 stroke patients	5 senior 10 British Bobath Tutors
Phase III	To assess the construct and concurrent validity of the TELER Indicators.	Using a correlation design to compare scores obtained when using the TELER Indicators and the MAS on 10 stroke units nationally distributed. The author scored patients weekly at the Royal Hallamshire Hospital Sheffield and visited each stroke unit 3 monthly over a one year period.	29 stroke patients	24 senior neurophysiotherapists
Phase IV	The collection of ' <i>original observations</i> ' to establish a theoretical basis for stroke rehabilitation.	Single case study design using four patients, the author scoring one patient daily for 4 months at the Royal Hallamshire Hospital	3 stroke patients	3 senior neurophysiotherapists

SECTION 2

CHAPTER 7

PHASE 1 IDENTIFYING THE NEED

7.1 Introduction

In a recent document, The Health of a Nation (DoH, 1990) the Government highlighted the need to develop effective measures of outcome from health care. As many physiotherapists expected, the document specifically identified the rehabilitation services for evaluation. In the light of the earlier review of stroke services, the potential cost to individual health authorities and lack of outcome literature, it is not surprising the Department of Health expected the therapy professions to measure their effectiveness in stroke rehabilitation.

Since the publication of the NHS Management Inquiry (Griffiths, 1983) and the implementation of resource management, physiotherapy managers, clinicians and researchers have endeavoured to quantify the more subjective stroke outcomes, thereby, providing hard numerical data essential to back any case for resources in a competitive market place (DoH, 1990).

This need for information about the effects of physiotherapy was reinforced by Tallis (1989) who quoting evidence submitted to the King's Fund Consensus Forum on Stroke Management suggests:

'Rehabilitation varies widely, mainly reflecting difference in resources but also detecting different beliefs. There is no absolute proof that individuals or collective services benefit patients. Should rehabilitation be abandoned?'

Tallis (1989)

Although an obvious over statement of the case, it demonstrates the need to identify measurable outcomes and reinforces the importance of research into clinical practice. Unfortunately, the problem for stroke physiotherapists lies in the selection of an

appropriate measure for use in the evaluation of either uni or multidisciplinary stroke outcomes.

There is now a wealth of literature on outcome measurements in physiotherapy (Wade, 1992b; Stewart, and Abeln, 1993; Cole et al., 1994), the CSP has recently published an information pack on the measurement of outcomes in physiotherapy and the DoH set up the UK Clearing House on Health Outcomes as a resource base for those requiring information on measurement in health care. Why then have stroke physiotherapist failed to reach a consensus on the most appropriate measure to use?

The Royal College of Physicians would appear to have little difficulty in the choice of a suitable measure as they have recommended the use of the Barthel Index (Mahoney and Barthel, 1954) in a number of documents (Royal College of Physicians, 1989; UK Clearing House, 1994). Likewise a number of medical colleges have similar ideas about the value of this measure of disability recommending it highly as a multidisciplinary measure in stroke rehabilitation (Collin et al., 1988; Wade and Collin, 1988; Wade, 1988; Wade, 1992b; Dombovy et al., 1986; Jongbloed, 1986). Others have suggested ways of changing the Barthel Index to improve its sensitivity (Shah et al., 1989; Shah, 1994; Barer, 1993) yet still therapists and others are unhappy about its uses in stroke rehabilitation (Ashburn, 1993; Bowling, 1991; Murdock, 1992; Smith, 1993). Perhaps the ultimate problem about the choice of a measure lies in the definition of 'appropriate' when applied to stroke rehabilitation undertaken by physiotherapists.

With this problem in mind, the main phase of this study to evaluate the process and outcome of Bobath physiotherapy could not be initiated until a measure had been selected that satisfied the clinicians, fulfilling the needs of both physiotherapists and their patients. Therefore the initial phase of the study had to achieve the following objectives:

- Identify the specifications for a measure of outcome from physiotherapy for stroke patients.
- Review existing reliable and valid measures of outcome used in stroke rehabilitation.
- Use the identified specifications to chose an appropriate measure for the evaluation of Bobath Physiotherapy for stroke patients.

7.2 The Approach

In order to identify the measurement needs of a stroke service, the Stroke Unit at the Northern General Hospital Sheffield was used to obtain qualitative data about both the physiotherapy programme being implemented and about the needs of those involved in the implementation of the programme.

Qualitative research has predominantly been the method of data collection in the social services, where research has involved the investigation of individuals in their own environment (Jensen, 1989; Taylor and Bogden, 1984; Polgar and Thomas, 1991). Unlike quantitative methods where predetermined responses are used to elicit information, qualitative research is used to identify what the requirements are by describing programs and the interactions, feelings, behaviours of those involved in the programme (Patton, 1987).

In his book on qualitative methods in evaluation Patton suggests the value of the evaluators visiting the unit becoming a '*participant observer*' talking to staff, observing events and studying documents used within the programme. In this way both Patten and Marshall and Rossman(1989) suggest that the researcher is able to enter the inner world of those who will be evaluated.

In order to establish the measurement needs of physiotherapists the author became a '*participant observer*' for three months on the stroke unit at the Northern General Hospital, Sheffield. Data was collected from interviews with a physiotherapy manager, a senior Bobath trained physiotherapist and a senior ward sister. Interactions between patients and physiotherapists were observed as were the assessment procedures and treatment sessions with individual patients. Existing documentation systems were reviewed as was the mechanism by which information was disseminated throughout the stroke unit.

In order to identify existing measures of physiotherapy outcome an extensive literature search of Medline and Cinahi was implemented using the on-line CD-ROM facilities at the Northern General Hospital. In this way medical, paramedical and nursing literature

on outcome measurement could be reviewed and measures compared against the specifications identified in the qualitative study.

7.3 Analysis of Qualitative Data

Content analysis was used to make certain inferences about the required nature of a measure to be used. As Marshall (1989) suggests, content analysis is a technique for: *'making inferences by objectively and systematically identifying specified characteristics of messages.'* As the process of content analysis is often difficult to define, an approach was adopted called the *'concept book approach'* (Brenner et al., 1985).

Using this approach the researcher has to become *'immersed in the data'* allowing idea elements and categories to emerge for interpretation and synthesis. In this way, all the data relating to the issue of measurement on the stroke unit were pulled together, then subdivided into coherent categories (Patton, 1987) that became the specifications for a physiotherapy measure.

7.4. Findings

Once the data had been analysed it became apparent that there were seven attributes required for a measure of physiotherapy outcome. See Table 9.

7.4.1 Feasibility

It was felt that an important requirement of any measure to be used in clinical practice was that the system had to be easy to use. The speed of completion was a crucial element as time was felt to be a major issue and that clinicians felt documentation detracted from patient treatments. Whilst clinicians realised the need for documentation, the recent changes to resources management over the past decade had resulted in numerous data collection exercises within the hospital that was felt to be time consuming and of little intrinsic value to the services.

TABLE 9 **Specifications to be Fulfilled by a Measuring System**

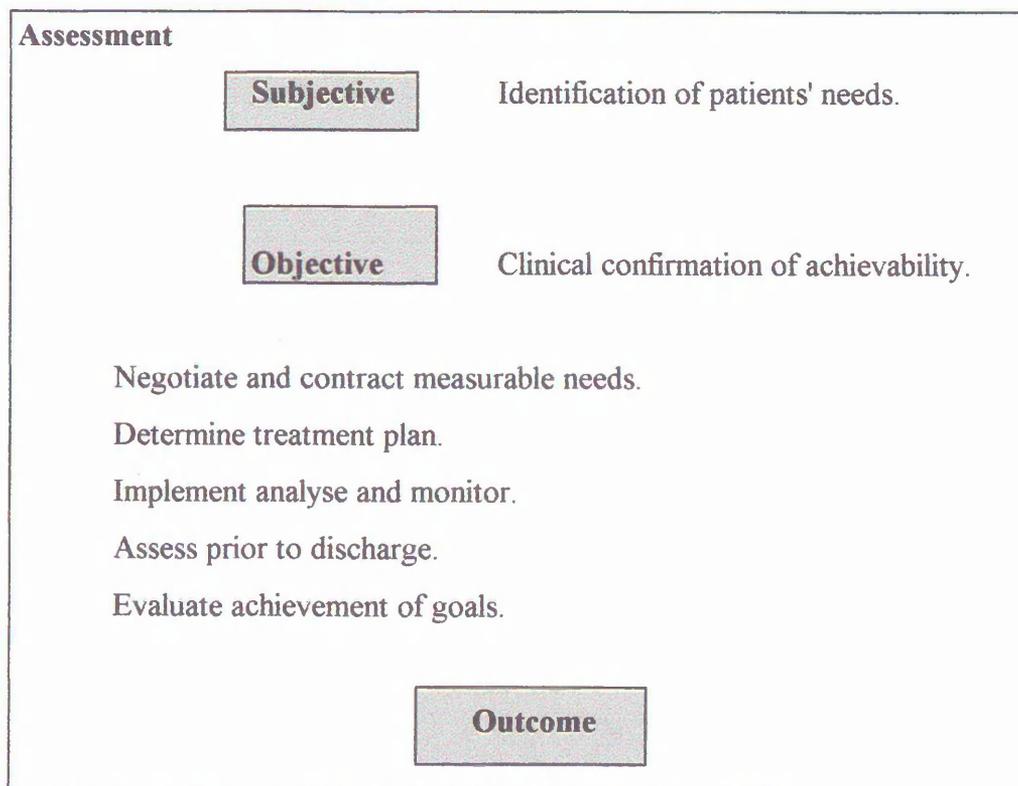
Feasibility	The system or instrument should allow rapid and easy administration.
Focus	The system should allow for a choice and definition of items specific to individual patient's needs, allowing for the definition and measurement of patient-oriented goals.
Precision	The system should be precise enough to allow for clinically significant changes in the patient's health status to be recorded.
Attribution	The system should provide statistically significant data, the outcome being the result of intervention, and not spontaneous recovery.
Auditable	The system should include the measurement of change in health status, and the documentation of therapeutic intervention, its timing and frequency.
Multidisciplinary	The system should have the potential for incorporating a multidisciplinary audit.
Logic	The system should meet the logical requirements identified for the establishment of scales of measurement.

7.4.2 Focus

It became apparent observing the assessment and therapy process, that physiotherapists on the stroke unit were tending to use a goal setting approach with individual patients. See Table 10. The assessments were subdivided into a subjective component when the patients individual needs or goals were identified. The objective assessment of muscle tone, posture, motor control, sensory and perceptual deficit and communication skills were used to establish whether the identified goals were achievable. A negotiation process then followed in which the patient, or their carers, came to an agreement on the short term goals to be reached as a pre requisite for more long term goals. Treatment plans were then formulated and implemented.

Whilst this was the observed process on the stroke unit, it was not reflected in the documentation system being used as this was a qualitative description of the patients ongoing subjective and objective state. It emerged therefore from the observation and documentation, that the process implemented required a measure to be focused on individually elicited patient's goals. This would ensure that the measure of outcome was a direct reflection of the physiotherapist ability to enable the patient to achieve his or her goals.

TABLE 10 The Goal Setting Approach in Stroke Rehabilitation



7.4.3 Precision

The process of identifying short and long term goals was consistent with the way in which the stroke physiotherapist implemented therapy. It was observed that small changes in the patient's ability to achieve a skill or task were felt to be important clinically as prerequisites to the achievement of subsequent elements of the task.

Physiotherapists were noted to work in '*steps*' or '*stages*' and when asked, were usually able to explain the importance of achieving the step or stage in terms of the patient's neurological deficit. It emerged therefore, that a requirement of any measure purporting to record the effects of physiotherapy must be precise enough to allow for these clinically significant changes or steps in the patient's health status to be recorded.

7.4.4 Attribution

The clinicians interviewed, expressed concern regarding the need to provide evidence that the changes they were inducing during early stroke rehabilitation, were the result of their intervention and not spontaneous recovery. Whilst they were fully aware that this did occur in a number of patients, there were other far-reaching issues about induced CNS adaption and maladaptation that required investigation. It was therefore felt that an important criteria for a measure was that it could provide information on the question of random change, or change induced by some form of intervention.

7.4.5 Auditability

It was felt, particularly by the audit team at the Northern General Hospital, that information was required, not only about the outcome of treatment, but also the number of treatments given, the type of treatment, the location and the staff mix on the unit being evaluated.

Clinicians felt that there was a danger in providing outcome information alone, as this was inevitably linked to other variables such as the timing of treatment, its frequency or location that might affect the ultimate outcome of intervention. It therefore became

apparent that any system of outcome measurement also needed to collect information on the structure of the service and the process of intervention.

7.4.6 Multidisciplinary

Whilst the initial phase of this research did not include observations or interviews of other disciplines within the stroke rehabilitation team, it was inevitable that meetings and joint therapy sessions would be observed during the course of the three month study.

In particular the case conference were observed and it became apparent any measure used should have the ability to record team goals. Whilst each individual profession might have their own goals negotiated with the patient, there was obvious overlap between goals and the present recording system did not facilitate the provision of information on how, or whether, the team was achieving the identified goals.

7.4.7 Logic

The question of logic arose in discussions on the measure recommended for use on the stroke unit by the medical personnel. The outcome measure suggested was the Barthel Index (see Table 12), an apparently reliable and valid multidisciplinary measure that provides a total score for each patient of between 0 and 20.

There was considerable concern about this method of summed scores, as patients lost their individuality when their scores were summed making it impossible to identify the exact difference in outcome between groups of patients. The interpretation of these anxieties would suggest that a specification for any measure of physiotherapy intervention must be that it fulfils the logical requirements of measuring scales in order for the information provided by the measure to be meaningful.

This set of categories became the specifications for a measurement model that was subsequently used in the decision making process following the review of existing valid and reliable measures in the published literature (Mawson, 1993a).

TABLE 12 Measuring Health Status: Existing Outcome Measures Available for Evaluating Physiotherapy Intervention in Stroke Rehabilitation

<u>Outcome Measure</u>	<u>Items Scored</u>	<u>Scoring System</u>	<u>References on Reliability & Validity</u>
Barthel Index Mahoney & Barthel 1965	10 ADL (including Bowel & Bladder)	Total Score 0 - 20	Gomperts et al., 1993 Gresham et al., 1980 Wade and Collin, 1988 Collin et al., 1988
Rivermead PDL Scale Whiting & Lincoln 1980 Lincoln & Edmans 1990	16 Self Care Items 15 Household Items	1980 version 1 - 3 1990 version Pass - Fail	Lincoln & Edmans 1990
Rivermead Motor Assessment (RMA) Lincoln & Leadbetter 1979	3 Sections on Gross Motor Function	1 = Yes	Collen et al., 1990
Functional Independence Measure (FIM) Granger et al., 1986 Functional Assessment Measure (FAM)	23 items in 7 areas of function, mobility and locomotion each having 3 items.	7 Point Scale for each item	Oczkowski and Barreca, 1993 Hall et al., 1993 Heinemann et al., 1993 Granger et al., 1990
Motor Assessment Scale (MAS) Carr & Shepherd 1985	8 Items of Motor Function plus muscle tone	0 - 6 Ordinal scale	Carr & Shepard 1985 Poole & Whiting 1988 Loewen & Anderson 1988
TELER Treatment Evaluation Le Roux Le Roux 1993	Clinically Significant Observable Function	0 - 5 Ordinal scale	
Motricity Index Demeurisse et al., 1980	Motor Improvement	4 Sets. Analysis out of 100	Collin & Wade 1990 Sunderland et al., 1989 Wade 1989 Parker et al., 1986
Fugl-Meyer Assessment (FMA) Fugl-Meyer et al., 1975	Motor Performance, Balance, Sensation, ROM, Pain	0 - 2 with a total of 100	Fugl-Meyer 1980 Dettman et al., 1989 Wood-Daughinee et al., 1990 Clarke et al., 1983 Sandford et al., 1993 Duncan et al., 1983 Malouin et al., 1994

The initial problem encountered when reviewing the literature on outcome measurement in stroke rehabilitation was the multidimensional nature of the rehabilitation process. A measure of outcome needs theoretically to address a number of domains that might include physical, psychological and social aspects of the patient's health status. As the purpose of this study was to evaluate the recovery of motor skills during the implementation of a Bobath physiotherapy approach, the review was limited to those measures of functional skill or activities of daily living.

Table 12 lists some of the measures currently recommended for use in the measurement of physiotherapy intervention in stroke rehabilitation and does include two used to measure different conceptual approaches to therapy. The references of validity and reliability only include those that support the listed measure.

7.5. Discussion

Before embarking upon a discussion of the measures identified in the review process, or using the specifications identified in this study to choose a suitable measure it might be valuable to discuss the specifications themselves in the light of current literature.

Inevitably clinical documentation systems must fulfil certain standards in order to comply with legal requirements. The Chartered Society of Physiotherapists in their publication on Standards of Physiotherapy Practice (Professional Affairs Department CSP, 1993), have included a section on documentations which clearly identifies the need for accurate recording of changes in health status and treatment inputs. The CSP have also published Standards for Administering Tests and Measurements for Physiotherapists (Professional Affairs Dept CSP, 1995), in which they state that the '*standards concern measurements that physiotherapists make in the clinical setting.*'

The standards for measurement describe the process whereby the physiotherapist assesses their patient and '*taking account of the patient's problem identified*', decides which aspect of the patient need to be measured. This is, in fact, quite a different concept to that identified during this initial study as it implies that the requirement is to measure some aspect of the patient whereas the results of this study would suggest that it is the patient's identified goals that need to be measured in some way.

The use of goal setting has been identified by a number of authors (Parry, 1982; Squires et al., 1991). Cott and Finch (1991) suggested that goal setting should become an integral part of professional practice, improving treatment effect by providing a negotiated contract of measurable achievement and that this process enables patients to gain maximum benefit from treatment. This argument would appear to support the findings of this study. Bohannon et al., (1988) in his study of patients goal identification in stroke rehabilitation, also supports this view, suggesting that taking account of functional goals is critical for the evaluation of treatments and that in doing so physiotherapists might expect greater compliance from patients.

The measurement of identified goals has also received considerable attention in the literature particularly in the management of chronic pain (Williams and Steig, 1987) and in the measurement of change in children with motor deficits (Palisano, 1992; 1993; Stephens and Haley, 1991). Ottenbacher (1989) discusses the value of goal attainment scaling in the documentation of '*therapeutic change and clinical accountability*' however, he does suggest that there are some concerns about the method of traditional goal attainment scoring.

The most commonly used method is that identified by Kiresuk and Sherman (1968) in which a 5 point performance scale ranging from -2 to +2 is used in which +2 is the most favoured outcome and -2 the least favoured. The weighting for each level is agreed before intervention and a goal attainment score (T) is computed at the end of the intervention process, based on the weighting and the outcome for each performance (Ottenbacher, 1989). Interestingly, the major criticism of the goal attainment scaling relates to the T score generated. Cytrynbaum et al., (1979) suggest that a major problem with the T scale is the fact that it relies on the reliability of the initial definitions and prediction of the 5 point scale by the evaluator. This is a valid argument as it is unclear on what the definitions of the goal attainment scale are based, and therefore both the validity and the reliability are potentially questionable.

The results of this study however, suggest that whilst a criteria for a measuring tool is that it measures individual patient's goals it also emerged that the measurement must record clinically significant changes in functional skills. The construct of clinically

significant change has also received some attention in the literature particularly in respect of its uses in the evaluation of treatment efficacy (Bain and Dollaghan, 1991).

In the original literature review the notion that clinical significance change should be an integral part of any study into the effectiveness of intervention and that observed clinically significant change could be used as a measuring tool, was identified. The literature suggest that clinical significance is a change in performance that can be attributed to intervention and not random change and that it can be *'shown to be important rather than trivial'* (Bain and Dollaghan, 1991).

The results of this study would suggest that a fundamental component of clinical significance change was that it was based on clinical knowledge. Physiotherapists were observed to work in steps or stages to achieve desired functional goals, the reasoning being based on clinical experience and clinical knowledge. The changes observed could therefore be described as clinically significant and used as definitions in a goal setting measurement approach.

One of the criteria for clinical significant change identified by Bain and Dollaghan (1991) was that the change must be a real change and not random. The results of this study would suggest that this is perhaps not the case as clinically significant changes occur whether they are the result of intervention or to random change and it should be the properties of the measuring tool that provide evidence of attribution

This initial study suggests that a measure of physiotherapy effectiveness must use clinically significant change but that clinical significance must be based on clinical knowledge and that the clinically significant changes must be those that occur during the achievement of individual patient orientated functional goals (Mawson, 1993a).

When reviewing measures of functional outcome for use in stroke rehabilitation, it became apparent whilst there were a number of standardised measures available, they had all been designed to measure the same items, regardless of the relevance to individual patients. Only one system known as the TELER system (Le Rouxs, 1993), enables the definition of individual patient orientated functional goals. However, this

system unlike the Barthel Index and the MAS had not been researched and there was no evidence of publications regarding the validity or reliability.

The Barthel Index in contrast, has been studied by a large number of researchers and appeared to be highly recommended by a leading authority on measurement in rehabilitation (Wade, 1992b; Wade and Collin, 1988). The validity of the Barthel Index as a global measure of disability cannot be disputed, however there are a number of authors who have questioned the suitability of using the index to measure the outcome of therapeutic intervention (Smith, 1993; Simpson, 1993; Murdock, 1992).

The results of this study suggest that there is concern about the method of scoring the Barthel Index, as summed scores result in a loss of unique data so that patients with the same scores can in fact have totally different disabilities (Mawson, 1995). The anxieties identified in this study are supported by Murdock (1992) in her critical review of the Index in which she repeatedly states that the summed percentage score has limited usefulness, '*such inappropriate use of statistics leads to inaccurate and misleading results.*' Smith (1993) states, that summing scores results in a loss of detail about how the score was achieved.

The Motor Assessment Scale (MAS) and the Fugl-Meyer Assessment (FMA) are both measures of motor performance, both developed as measures of different approaches to stroke rehabilitation. The MAS measures a patient's performance of everyday activities on a 7 point scale, each point of which represents a motor component of the named activity (Carr et al., 1985). There are eight areas of motor function and one relating to muscle tone. How this measure was developed is not documented, therefore the validity of the definitions as a measure of the motor learning approach is difficult to assess.

The reliability of the MAS has been tested using twenty physiotherapists scoring videos of five stroke patients in the interrater reliability test and 14 in the test-retest reliability study where Lynne, one of the authors, assessed the patients twice (Carr et al., 1985). The data collected from both studies was analysed using Pearson product-moment correlation coefficients. Interestingly, there has been some concern about the use of this method of analysis in the literature (Sheikh, 1986; Bland and Aitman, 1986), suggesting that the correlation coefficient often overestimates the degree of true agreement, and

more importantly, may conceal important disagreements. Sheikh suggests the use of Kappa statistic in both interrater and in test-retest studies. It would be interesting to apply the Kappa statistic to the original data produced in Carr and Shepherd's study.

The FMA was developed by Fugl-Meyer and co-workers (Fugl-Meyer et al., 1975; 1980) and is based on a motor recovery pattern originally described by Twitchell (1951). The FMA measures the stroke patient's ability to perform a series of upper and lower limb activities and includes items on balance, sensation, range of movement and pain. Each item is scored on a 3 point ordinal scale. Again most of the reported studies of both reliability and validity (Clarke et al., 1983; Malouin, 1994; Duncan, 1983) used the Pearson product-moment correlation coefficient so that whilst there may be some agreement between the scores what is important clinically is the level of agreement between the scores (Bland and Aitman, 1986).

Neither the MAS or the FMA were chosen for this study as they were designed to measure the motor programme approach and the Brunnstrom approach to the treatment of stroke patients and the purpose of this study is to investigate the Bobath Approach. The Barthel Index was the most tested measure of disability however, the method of summing data and its overall lack of responsivity to clinically significant change suggested that it was not appropriate for the task in hand. FIM and FAM was totally unfeasible as the 30 items included preclude its use in a clinical setting (Hall et al., 1993) and there is some doubt regarding its ability to measure change over time (Dodds et al., 1993). The only measure that appeared to fulfil all the specifications was the TELER system and it was therefore this method of evaluation that was chosen for the proposed study.

8. TELER: THE FORM THAT COUNTS

8.1 Introduction

The TELER system is a concept of evaluation developed during the 1980's by Le Roux (1993) Principal Lecturer in health care research at Sheffield Hallam University. The inception of the concept resulted from a request by a group of paediatric physiotherapists for help in demonstrating the effects of their therapeutic intervention. Paediatric physiotherapists throughout the UK had been devastated by a paper published in a leading journal by Wright and Nicholson (1981) in which the findings of their study suggested that physiotherapy was of little value to children with cerebral palsy.

This initial request was followed by collaborative work that resulted in the development of the TELER system. Whilst the therapists provided the clinical expertise, Le Roux used his extensive knowledge of research methods and mathematics to formulate a unique method of evaluating practise. To understand the TELER system fully, the TELER concept on which it is based must be identified, followed by a description of the TELER indicator, the measuring scale that traces change when the TELER system is used.

8.2 The TELER Concept

When developing a conceptual framework it is important to identify firstly, the characteristic of the concept (Hyman, 1968; King, 1971; Sieloff Evans, 1991) and secondly, assumptions or '*givens*' on which the concept is based. In their book on nursing research, Woods and Catanzaro (1988) state that an assumption is:

'a statement of principles that is accepted as true on the basis of logic or reason.'

Woods and Catanzaro (1988)

8.2.1 The Characteristics of TELER

TELER has two components: the TELER method of clinical note making and the TELER method of measurement. The TELER method of clinical note making provides a simple, flexible and effective system for presenting clinical information. This information includes not only the treatment input, but also how the patient changed during the episode of care enabling the evaluation of the relationship between therapy and clinically significant change.

Any method of measurement can be used with the TELER method of clinical note making provided it, firstly, satisfies the requirements of measurement theory, and secondly, measures change effectively. The TELER method of measurement does both, and requires the use of clinical knowledge to support the definition of clinically significant change recorded in the ordinal scale of the TELER indicator (Le Roux, 1995).

The evaluation provided by TELER is a valuable tool for both clinicians and managers as it ensures that any change or, more importantly, lack of change can be investigated and action can be taken to alter the care plan for that patient without undue delay. It may be that the therapy input requires modification, or that another member of the multidisciplinary team needs to implement or change their input. This method of clinically auditing intervention is both dynamic and efficient.

TELER also provides information about the pattern of change or lack of change recorded in any individual patient showing whether the pattern recorded is unlikely to have occurred by chance, and therefore is attributable to something (Le Roux, 1995b). This method of analysing the patterns of change is known as TELER evaluation, in which the probability of chance occurrence is obtained from the multinomial distribution function (Le Roux and Lynne, 1991).

Having obtained the probability level of chance occurrence for each profile or pattern, the patterns are arranged in a hierarchical order in which the probability levels are added to obtain totals, that *'approximate to the well known areas under the normal*

distribution curve.' (Le Roux and Lynne, 1991). This enables the classification of patterns into 5 categories:

- * strong evidence of effect
- * moderate evidence of effect
- * no evidence of effect/no effect
- * moderate evidence of no effect
- * strong evidence of no effect

Le Roux (1993)

Whilst this facility of the TELER system is extremely valuable in the provision of evidence of chance or random occurrence it can never provide proof that the intervention being evaluated has caused the change as there are many variables that may have resulted in the change occurring. For example, it may be the result of drug therapy, physiological factors such as an alteration in electrolyte balance, blood gases or blood pressure or a number of interventions from the multidisciplinary team. However, if the system were used in accordance with the requirements of appropriate research design (Le Roux, 1995a) then evidence of effective intervention can be provided.

The specification for the definition of the code of a TELER indicator (Le Roux, 1993; 1995a) is such that a change denoted by the difference between two successive codes is unlikely to have occurred spontaneously or by chance. The need to use the probability model to classify a pattern of change for evidence of effect is therefore largely non-existent, and is ignored by clinicians delivering treatment.

8.2.2 The 'Givens' of TELER

The concept of TELER is derived from a series of assumptions or self evident truths and are as follows (Le Roux, 1993, 1995a):

- The essential purpose of treatment is to induce or prevent change.
- Effective treatment is patient centred and patient orientated.
- Effective treatment is grounded in theory.

- Change, or lack of change, occurs in clinically significant steps over clinically significant periods of time.
- Change occurs naturally, spontaneously and the model for spontaneous change is a constrained random walk.
- Change, or lack of change, which is unlikely to have occurred spontaneously or by chance was induced.
- The effects of clinically significant changes are not necessarily measurable on an interval or ratio scale, but are observable.

8.3 The TELER Indicator

The TELER indicator is a 6 point ordinal measuring scale coded from 0 to 5, the purpose of which is to trace the pattern of clinically significant change. The title of the indicator denotes the goal to be achieved during intervention and is negotiated rather than imposed on the patient or their carers. The codes of the ordinal scale describe observable, patient centred treatment objectives in the form of outcomes or actions that are clinically significant because they can be justified by appropriate knowledge and require amounts of therapeutic input that are clinically significant because they can also be justified by appropriate knowledge.

The concept that clinical change is only significant if it can be supported by clinical knowledge, ensures that the definitions of the points of the ordinal scale fulfil the requirements specified by the theories of measuring scales (Stevens, 1946), that is, that they have the properties of transitivity, asymmetry and connectivity. This concept also ensures that the indicator has face validity.

The purpose of the TELER indicator is to trace change or lack of change in either the ability to perform a voluntary or involuntary functional or non functional activity, or in the patients/carers level of knowledge. Two of the three basic types of TELER indicator, namely, the Functions Indicator and the Component Indicator are of particular importance for this study of functional recovery following stroke. See Figure 6.

Figure 6 CLASSIFICATION SCHEME FOR TELER INDICATORS

- **Quiz Style Indicators**

- **Component Indicators**
- Physical Function Indicators (PFI)
- Non Physical Function Indicators (NPFI)

- **Function Indicators**
- Team Indicators
 - Ordinary Indicators
 - PFI
 - NPFI
 - Standard Indicators
 - PFI
 - NPFI
 - Frame Work Indicators
 - PFI
 - NPFI
 - Management Indicators
 - Treatment Delivery Indicators
 - Management Action Indicators
 - Appliance Performance Indicators

From Le Roux 1995b

A physical function or motor task indicator records, over-time, change and lack of change in a patient's ability to perform a named motor task. When the clinically significant stages in the achievement of this task occur in hierarchical order they are denoted by the codes of a TELER indicator to provide a measuring scale which fulfils the requirements of measurement theory previously identified (Stevens, 1946; Krebs, 1987), and is known as a TELER Function Indicator.

There are two types of function indicator: the ordinary function indicator, which reflects the individual patients' needs, and the standard function indicator which identified the needs of therapists reflecting the characteristics of the deficit.

The TELER component indicator records change, and lack of change, in a patient's ability to achieve a set of outcomes that are not placed in hierarchical order. The codes of this type of indicator denote the number of tasks or activities that the patient can achieve in this way fulfilling the requirements of measurement theory.

Both the function indicator and the component indicator record change and lack of change over time. Both are useful in comparing the outcomes of intervention across service areas.

8.4 Discussion

From this presentation of the TELER system it can be seen that it appears to fulfil the model of physiotherapy measurement in stroke rehabilitation identified in Phase I of this study. Theoretically the TELER system should be feasible to use in clinical practise as it does not rely on extensive qualitative note making as do other methods and unlike measuring tools like FIM and FAM only those indicators relevant to the individual patient are recorded.

Evidence of the feasibility of using TELER has been provided (D'Souza, 1996) in a study comparing the feasibility of using the TELER system and the Barthel Index. The results of this study found that, the time taken for both outcome measures was similar, however, the TELER system provided a *'greater quantity and quality of information'* (D'Souza, 1996). Whilst in theory the system is easy to use, one aspect that may be more time consuming is related to the requirement of the system that the clinically significant definitions of the TELER indicator must be developed by the physiotherapist using their clinical knowledge. This process could inevitably be incorporated into the in service training programmes of individual departments. However, the time expenditure must be balanced between time lost in patients' treatment and gains in knowledge and availability of useful clinical information that would benefit both patients and physiotherapists.

It can be seen that the concept of TELER is based on a number of identified assumptions or 'givens' one of which states that '*effective treatment is patient centred and patient orientated*'. This basic assumption should ensure that the system, when used in stroke rehabilitation, allows for a choice and definition of indicators items specific to individual patient's needs, so fulfilling the requirement of *focus*, one of the specifications for an outcome measurement in stroke rehabilitation identified in the initial phase of this study. See Table 9. This should therefore facilitate the suggested goal attainment model of practise used within the stroke unit at the Northern General Hospital.

The process whereby the physiotherapists identify and confirm patient or carer goals during the assessment (Table 10) can be supported by the transfer of goals into TELER indicators using clinical knowledge. In this way TELER would provide the link between the process of stroke rehabilitation and the measurement of the outcome of that rehabilitation (Mawson and McCreadie, 1993b, 1994a, 1995a; Mawson 1993a; Mawson, 1994c).

A further requirement of a measure of physiotherapy outcome in stroke management was that the measure must have precision, this having been discussed in relation to measures such as the Barthel Index. The fundamental concept of TELER is that it measures clinically significant change, or lack of clinically significant change, and that these definitions identified by physiotherapists must be supported by knowledge.

The findings of the initial phase of this study would suggest that physiotherapists using the Bobath Approach work in steps or stages in order to achieve the ultimate goal of normal movement patterns. If TELER is able to record these clinically significant steps then the system must have *precision* or responsiveness, Guyatt et al., (1987) defining this property as being the ability to '*detect minimal clinically important differences.*'

One obvious question will remain about the reliability of such a system as it has been well documented in the literature that an increase in sensitivity may result in a reduction in both intra and interrater reliability. However, the sensitivity of a measure relates to the size of a unit of measure, where that measure is an interval scale, a reduction in the size of the unit to increase the sensitivity will result in a reduction in the reliability of the measure. With ordinal measuring scales, the purpose of which is to evaluate outcomes,

the opposite is true as there is no unit of measure. It is the precision of the definitions of clinically significant differences, where they are based on sound theory, that increases the responsiveness of the scale. This increased responsiveness will result in an increase in the reliability of the measure, provided, the users have the same level of theoretical knowledge.

Physiotherapist working in the area of stroke rehabilitation require a measure to provide some evidence of *attribution*. As previously identified in the literature review, and discussed in Phase I of this study, changes in the health service and a need to provide information about effective practise have contributed to this urgent need.

If the specifications for the definitions of the codes of a set of TELER indicators are fulfilled, then any change in a patient's function denoted by the difference between two successive codes is unlikely to have occurred spontaneously or by chance. Whilst this probability model is largely ignored by clinicians, if the TELER system were used in clinical practise using a research design such as the single case study, then it might be possible to provide evidence of the characteristics of effective physiotherapy intervention during stroke rehabilitation.

Information proved by TELER, not only includes patterns of change, or lack of change, but also information about the process of intervention. In this way physiotherapists can review daily the patient's profile of TELER codes and relate the patterns directly to the physiotherapy programme or other events documented in the comments section of the form.

This should facilitate effective '*clinical audit*' enabling physiotherapists to determine whether treatment should be modified or changed, the frequency or length of treatments should be altered, the training of therapists requires attention, or the timing and location of input requires change (Mawson and McCreadie, 1993b).

Whilst this study was designed specifically to evaluate the recovery of stroke patients during Bobath physiotherapy, the system can obviously be used by any of the *multidisciplinary* team (Mawson, 1995e). At this point in the study, a number of hospitals such as Retford and Lincoln were using TELER in the development of patient

care plans. However, these had not been documented in the literature so that whilst, in theory, the system can provide evidence of multidisciplinary outcomes, this has not yet been supported by evidence in the literature.

As the TELER system appeared to fulfil the measurement specifications identified in Phase I, it was chosen as the measure to be used to identify the characteristics of recovery. However, in order to compare the recovery of function during treatment both ordinary function indicators and standard function indicators were required to be used in a single case study design. At this point in the research process, neither of these were available and therefore Phase II and Phase III had to be undertaken to firstly, investigate the function indicators required by stroke patients and secondly, validate the definitions of those indicators as Standard Function Indicators for use in future stroke research.

CHAPTER 9

9. PHASE II MODIFYING AND DEVELOPING THE MEASURE

9.1 Introduction

Having fulfilled the objectives of Phase I the TELER method was chosen as the most appropriate measure for use in the final phase of this study. However, the documentation of the system required some modification to provide further information about the patients treated during the study.

As previously reviewed when trying to evaluate stroke intervention outcomes the nature of the initial impairment and the level of the presenting handicap (WHO, CIDH, Geneva, 1980) need to be recorded (Wade, 1992b). In the previous chapter on the TELER system it was established that the system consists of two components, the TELER method of clinical note taking and the TELER method of measurement. For the purpose of this study it was decided to include within the method of note taking an assessment of both initial impairment and handicap in order to identify the characteristics of the client group involved. A copy of the basic TELER form prior to the inclusion of further assessment information is included in appendix 1.1.

In the original literature review the problem facing physiotherapist in stroke evaluation lies in the multidimensional nature of stroke impairments (Fries, 1982). There are few scales that measure impairment alone, however, one such scale that appears to be valid and reliable (Wade, 1992 b; Goldstein et al., 1989) is the National Institute of Health Stroke Scale (Brott et al., 1989). Whilst the original version had 15 items that included all impairments that might occur following a stroke, only 5 of these were scored and included on the TELER form see appendix 1.2.

To determine the initial level of handicap the Rankin Scale (Rankin, 1957) was selected as this appeared to be a reliable (Van Swieten et al., 1988) and simple measure of the patient's level of dependence. The scale is scored from 0 to 5, 0 being no symptoms, and 5 being severely handicapped and totally dependent. As well as classifying the severity of the stroke, the Royal College of Physicians (1989) also suggest the importance of

identifying the location of the stroke when evaluating treatment approaches and outcomes. Where possible this information was documented with the Rankin score and included in appendix 1.4.

A further issue regarding the use of the TELER system relates to the validity of the TELER method of measurement, the TELER indicator. As reviewed in the literature (section 3.3), validity in its simplest definition is that a measure, measures what it is intended or supposed to measure.

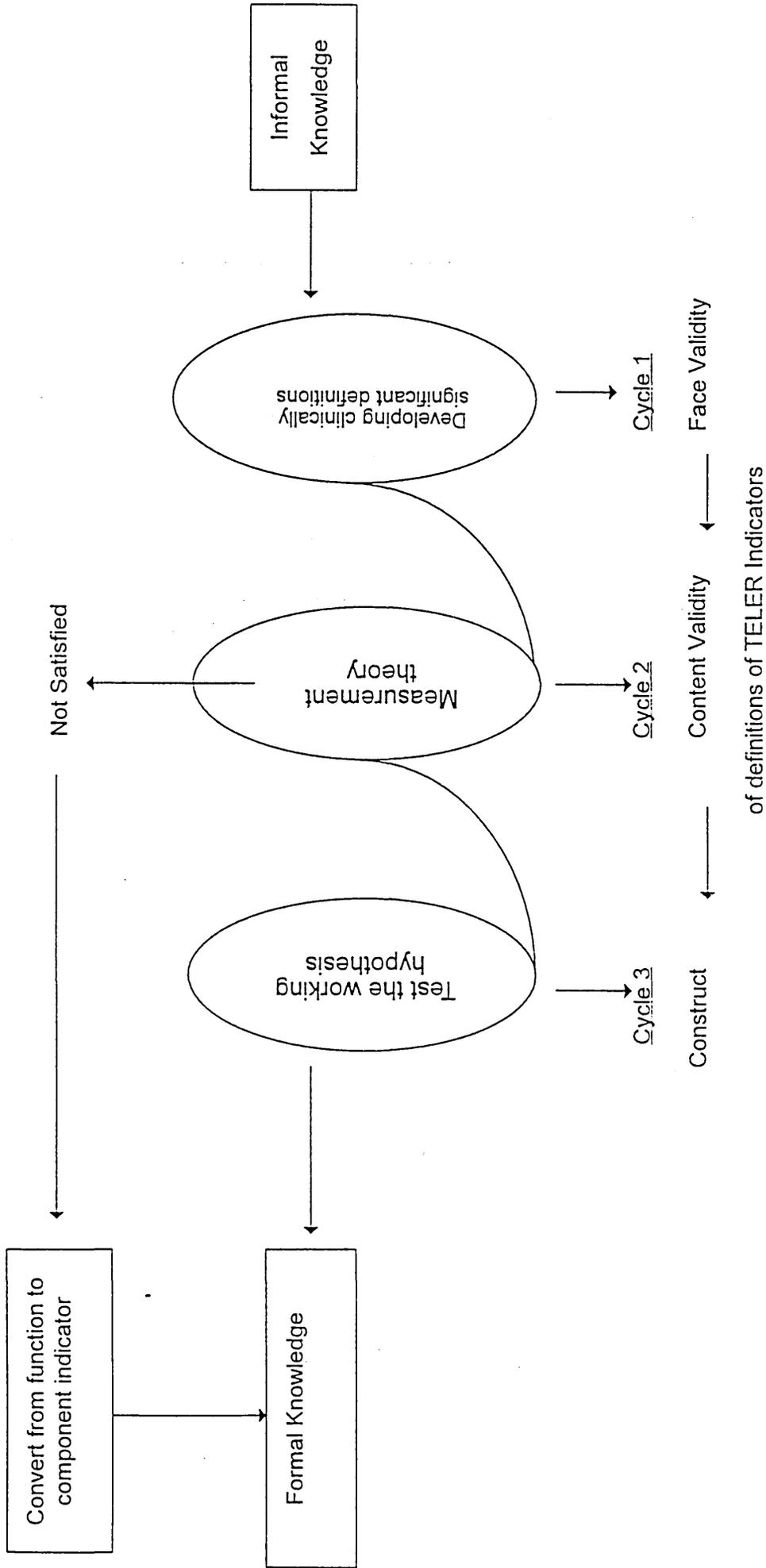
The TELER indicator is patient centred and knowledge based using clinically significant steps to record the achievement of patients goals. This will inevitably ensure the Face validity of the measure if the TELER Indicators are developed by the appropriate professional. However, there are two important elements of knowledge that are relevant to both the development of validity, and to the use of TELER during this study for the development of knowledge.

Theoretically, knowledge can be divided into clinical or empirical knowledge, and formal knowledge that which is based on '*proven scientific*' evidence. The TELER indicator requires the use of clinical knowledge and experience to develop the clinically significant steps of the TELER indicator, however it might be suggested that this clinical knowledge may not be based on sound theoretical evidence.

Whilst the Face validity of the indicator would be undisputed other levels of validity may need to be satisfied. This developmental process will however bring its own rewards as the process itself, will inevitably enable the identification of assumptions or working hypothesis for subsequent testing. This in itself will provide evidence that then becomes formal knowledge, see Figure 7.

When reviewing the literature on validity (Pogar and Thomas, 1991; Herbert, 1991; Fitz-Gibbon Morris, 1988; Wade, 1992b; Cole et al., 1995) there appear to be a number of different types of validity, the names of which vary from one author to another. However, the two most important types of validity to be developed during phase II and tested during phase III of this study are content validity, and construct validity.

Figure 7 The Validity of the TELER Indicator



Construct validity relates to the theoretical basis underlying the definitions of the codes of an indicator and requires theoretical knowledge to explain the test or measure, and what is, in fact, being measured (Herbert, 1991). To ensure construct validity '*experts*' within an area are required to take part in the validation process. Content validity (Polgar and Thomas, 1991) refers to the definitions included in the measure. They should relate to the construct being measured (Wade, 1992c) and also cover a wide range of that construct ensuring that the measure achieves the stated purpose. In this respect both the patient and the clinician treating the patient require to be involved in the validation process.

As these issues regarding the validity of measuring tools needed to be addressed before the measure could be used to evaluate physiotherapy intervention, the aim of this second phase was to develop a set of TELER outcome indicators that had construct and content validity for use by Bobath physiotherapists treating acute stroke patients. The objectives to be fulfilled by Phase 11 were therefore as follows:

- * To recruit a group of senior physiotherapists who had attended post graduate training in the Bobath Approach.
- * To train the physiotherapists in the use of the TELER system.
- * Use the TELER system for 12 months identifying individual patient's goals and developing the definitions of the TELER indicators.
- * Contact the British Bobath Tutors group and use their expert knowledge to critique the clinically developed definitions of the TELER indicators.

In this way clinical knowledge and expert knowledge would be used to develop the TELER indicators, but more importantly this would be achieved in a patient driven clinical setting. This would ensure that the measure, when developed, would fulfil the needs of both the physiotherapists and the stroke patients.

It was also anticipated that the validation process might enable the development of assumptions regarding the Bobath Approach as appropriate knowledge is required to justify the clinically significant definitions of the indicators. These assumptions re-stated as hypotheses could then be tested in the final stage Phase IV of the study potentially

providing new knowledge regarding both the process and the recovery of motor function.

9.2 The Approach

As the nature of this phase was to use clinical and expert knowledge to develop a set of TELER Indicators for use in stroke rehabilitation a consensus regarding the definitions of the clinically significant steps of the Indicators was essential. Therefore the most appropriate research methods that could be used in this phase were both the Delphi technique and the consensus meeting research method.

The Delphi method was originally developed by the Rand Corporation in the USA in 1950 (Dalkley, 1969; Sackman, 1975; Pill, 1971; Rowe et al., 1991; Jones and Hunter, 1995). The basic principle of the Delphi technique is that experts in a given area participate in a data collection exercise, the purpose of which is to reach a consensus regarding a given topic (Walker, 1994). There are four characteristics of the technique (Miles-Tapping et al., 1990; Pill, 1971; Rowe et al., 1991) each relevant to the design of this phase of the study:

- Anonymity enabling individuals to use their clinical knowledge without the potential influencing bias or inhibition of ideas by colleagues.
- Feedback at certain stages during the process ensuring that participants become aware of the ideas provided by other experts in the area. The process allows participants to modify or change their views in response to this information
- A summary of the data or information is provided for final review by participants.
- The use of '*informed*' respondents is a key characteristic of this technique in which the knowledge of valued experts is used to develop priorities for a given topic (Lindeman, 1975; Goodman, 1987).

The consensus method for both medical research (Jones and Hunter, 1995; Kitzinger, 1995) and in the area of measurement development (Boyce et al., 1993; Thorn and Dietz, 1989) have become increasingly popular over the past decade being used frequently by the Kings Fund Centre to provide a professional consensus on a given topic

(Partridge, 1994; Whitham, 1990). During the consensus meeting or workshop agreement is hopefully reached on a set of consensus statements about a given topic.

As both methods of data collection would contribute to different aspects of the measurements validity a combination of the two approaches was used in this second phase of the research programme.

9.3 Method

Five stroke units were recruited either through the TELER network or through the regional ACPIN group, all of which were located within the Trent Regional Health Authority. (See Appendix 1.3.) All of the participating physiotherapists had attended post graduate Bobath courses to a varying degree, see table 11.

TABLE 11

Post Graduate Qualifications of Physiotherapists Involved in Phase 11

	Basic Bobath Course	Advanced Bobath Course
Senior Physiotherapists	2	4

In order to achieve the two different levels of validity three rounds were used in the development of the TELER Physical Function Indicators the first two, using the clinical expertise and knowledge of the 6 stroke physiotherapists listed above, to achieve content validity. The third, using the highest level of '*expert knowledge*' available, to establish the construct validity of the Indicators.

9.3.1 Round One:

Following instruction in the use of the TELER system all new patients admitted to the stroke unit were assessed and their treatment documented with TELER. This process included the process identified in Phase 1, in which patients were asked to identify their functional goals (section 7.4.2). As the ultimate purpose of this study was to investigate the recovery of motor function during physiotherapy only those goals related to physical tasks were included in the data collection exercise.

The physiotherapist then used his or her clinical knowledge to define the clinically significant steps required to achieve the identified goal. This then became the TELER indicator and was then used to trace the patients' pattern of change or lack of change during treatment. These indicators were then collected to form the results of the first Delphi round.

Exclusion Criteria: The main purpose of this study was to develop a measure for use in the clinical setting as well as for research purposes, the only exclusion criteria therefore were severe dementia or short term memory loss and any patient who was not independently mobile prior to their stroke.

Inclusion Criteria: The initial literature review suggested, that the most commonly occurring stroke was the cerebral infarction therefore, only those patients who fulfilled this diagnosis either confirmed by clinical presentation or if available and current practice by MRI were included. Only patients who had suffered a major stroke, that is patients in whom the stroke had lasted for longer than one week (Royal College of Physicians, 1989), were included in the data collecting exercise.

Assessment: Each physiotherapist used the assessment protocol of the unit concerned however, information was also obtained regarding the patients' presenting level of impairment and handicap using the Rankin scale and the NIH scale. The exact time frame of the stroke and the location if available were also documented. This information together with the identified problem list was also included on the TELER form.

Informed Consent: Whilst this first round became part of the routine physiotherapy process, all patients involved were informed about the nature of the data collection, all information provided on the TELER forms was anonymous each form being coded to maintain individual patient confidentiality.

9.3.2 Round Two

From the data base a first draft catalogue of new TELER Physical Function Indicators was developed. This included all the goals identified in round one, each with identified code definitions. The catalogue was distributed to all involved physiotherapists, one month prior to a consensus meeting held at Sheffield Hallam University.

The consensus meeting was attended by all the physiotherapists concerned, the author and an independent observer. Discussion regarding the individual definitions of the

functional indicators involved the identification of knowledge underlying the clinically significant steps identified. The meeting culminated in the second draft catalogue of TELER Physical Function Indicators.

9.3.3 Round Three

As the purpose of this study was to identify the process and outcome of the Bobath Approach, the highest level of clinical knowledge of that approach was the British Bobath Tutors Association (BBTA). It was anticipated that this would enable the development of the construct validity of the indicators ensuring that they related to the theoretical basis of the Bobath (Normal Movement) Approach.

The BBTA co-ordinates and implements both National and International basic and advanced Bobath courses for Physiotherapists and Occupational Therapists. A Bobath Tutor trains for five years attending the twice yearly BBTA study weeks, in which the tutors update their knowledge of neurophysiology and developments in the management of the neurological impaired patient.

Following a presentation to the BBTA, they agreed to participate in the study and received copies of the second draft catalogue two months prior to a consensus meeting held in a hotel in the Midlands. Having reviewed the catalogue during the two month period, nine tutors attended the consensus meeting chaired by Alan Bass, the Association Chairman. The author acted as a scribe during the meeting which lasted six hours, taken in four one and a half hour sessions. Following this meeting the indicators were rewritten, where necessary, and became the Indicators used in Phase III and IV.

9.4 **Results**

9.4.1 Validation Process

A total of 41 patients were included in the data collection exercise of Round One, their characteristics being identified in Table 13. During the assessment process prior to treatment, 192 function tasks were requested by the 41 patients and these are listed in Appendix 2.1. Whilst there were 192 functional tasks recorded during the 12 month

period of Phase 11, it can be seen that there were, in fact, only 15 core functional tasks listed in Table 14, with 7 other activities that were a mixture of treatment goals and psychological indicators, included in Table 15. The tables also record the frequency of requests for each of the tasks. It can be seen that sit to stand, stand, walk and sit were the most frequently requested tasks.

TABLE 13

Summary Characteristics of Patients Involved in First Delphi Round

Mean age	Location of stroke	Mean Rankin score	Total nos goals	Number of 'step and plateau'	% of total
66 SD 13.46	20 left 20 right 1 NA	4	192	118	62%

TABLE 14

Results of First Delphi Round: Functional Skill Requested and Frequency of Request in Ranked Order

Functional Task	Frequency
Sit to Stand	34
Stand	32
Walk	23
Sit	20
Transfer	16
Step	14
Stand to Sit	14
Stairs	7
Drinking	6
Side Step	4
Forward Step	4
Toileting	3
Lying to Sitting	3
Rolling to Sitting	3
Sit to Lying	1

A total of 184 Functional Tasks were requested, some were combinations of functional tasks and therefore counted as such. (See Appendix 2. 1.)

TABLE 15

Other Activities Requested:

Request	Frequency
Eliminate Positive Support	1
Hand Activities	1
Ball Throwing	1
Rise from Floor	1
Shoulder Activities	1
Motivation/Attention	2
Associated Reactions	1
Total	8

Each of the requested functional tasks was subdivided into the 6 points of the TELER ordinal scale and where there was an overall consensus in the definition of the clinical steps these were included in the first draft catalogue for use with stroke patients, see Figure 8. An example of an Indicator in this first catalogue is shown in Figure 9.

The second round meeting of the clinicians, held at Sheffield Hallam University, resulted in a number of changes to this first catalogue of Indicators. It took three hours to reach a consensus on the clinical steps of the Indicators. An example of how the indicator above was changed is given in Figure 10. The clinicians used their clinical knowledge to agree that this indicator was not in an appropriate hierarchical order, therefore, one of the theories of measurement on which the TELER system is based was not satisfied.

Clinicians reported, during this meeting, that this indicator was incorrect as patients' could often achieve a score of 2, 3 or 4 but not a score of 1, the resulting plateau in the patients pattern of change was not clinically acceptable as the patient was, in fact, making progress.

FIGURE 8

Results of First Delphi Round: Functional Tasks Included in First Catalogue

<p style="text-align: center;"><u>Physical Function TELER Indicator</u></p> <p style="text-align: center;">Lying</p> <p style="text-align: center;">Rolling</p> <p style="text-align: center;">Lying to Sitting</p> <p style="text-align: center;">Sitting to Lying</p> <p style="text-align: center;"><u>Independent Sitting</u></p> <p style="text-align: center;"><u>Dynamic Sitting</u></p> <p style="text-align: center;">Sitting to Standing</p> <p style="text-align: center;">Standing to Sitting</p> <p style="text-align: center;"><u>Independent Standing</u></p> <p style="text-align: center;"><u>Dynamic Standing</u></p> <p style="text-align: center;">Floor Sitting to Standing</p> <p style="text-align: center;">Up Stairs</p> <p style="text-align: center;">Down Stairs</p> <p style="text-align: center;"><u>Component Physical Function Indicators</u></p> <p style="text-align: center;">Transfer Bed to Chair and Chair to Bed</p> <p style="text-align: center;">Toileting</p> <p style="text-align: center;">Functional Walking</p> <p style="text-align: center;">Wheelchair Mobility</p> <p style="text-align: center;">Functional Arm</p>

The clinicians reasoned that the Clinical Step 1 '*able to move bottom forwards on chair*' was a more complex task than 2, 3 or 4, requiring the patient to be able to shift their weight laterally and bring the opposite hip forwards using a rotation component in the trunk. This indicator therefore, changed to become two indicators, Edge Sit to Stand and Chair Sit to Edge. See Figure 10.

FIGURE 9 TELER Indicator First Delphi Round

TELER Indicator First Delphi Round

Indicator Name: Sit to Stand

- 0: Unable
- 1 : Able to move bottom forward on seat
- 2 : Able to flex hips and transfer weight over feet
- 3 : Able to lift bottom off chair
- 4 : Able to extend knees, hips and trunk
- 5 : Able to stand with assistance.

In this way the development of the TELER indicator had enabled the clinicians to prove that one aspect of motor control was more difficult to achieve than another. The problem, was not one of correct definition, but one of complexity of task.

FIGURE 10 TELER Indicator Second Delphi Round

TELER Indicator Second Round

Indicator Name: Edge Sit to Stand

- 0: Unable
- 1 : Able to initiate movement with pelvis
- 2 : Able to transfer weight over feet
- 3 : Able to lift bottom off chair
- 4 : Able to extend (knees, hips and trunk)
- 5 : Able to stand

The second round which included the clinicians consensus meeting, resulted in a second catalogue of TELER Physical Function Indicators, the content of which is listed in Figure 12. It was this catalogue that was critiqued by the BBA and discussed at the final consensus meeting, the result of which became the final catalogue the contents being listed in Figure 13.

FIGURE 12

Results of Second Delphi Round and Consensus Meeting of Clinicians Involved:
Functional Tasks Included in Second Catalogue

<p style="text-align: center;"><u>Physical Function TELER Indicators</u></p> <p style="text-align: center;">Lying</p> <p style="text-align: center;">Rolling</p> <p style="text-align: center;">Side Lying to Sitting</p> <p style="text-align: center;">Independent Sitting</p> <p style="text-align: center;">Dynamic Sitting</p> <p style="text-align: center;">Independent Step to Step Stand</p> <p style="text-align: center;">Independent Step from Step Stand</p> <p style="text-align: center;">Walking</p> <p style="text-align: center;">Up Stairs</p> <p style="text-align: center;">Down Stairs</p> <p style="text-align: center;"><u>Component Physical Function TELER Indicators</u></p> <p style="text-align: center;">Bed Mobility</p> <p style="text-align: center;">Transfer Bed to Chair/Chair to Bed</p> <p style="text-align: center;">Independent Wheelchair Transfer</p> <p style="text-align: center;">Toileting</p> <p style="text-align: center;">Functional Walking</p> <p style="text-align: center;">Wheelchair Mobility</p> <p style="text-align: center;">Electric Wheelchair Use</p> <p style="text-align: center;">Functional Arm</p>

FIGURE 13

Physical Function Indicators Ability to Accept Base of Support

Maintain Lying

Maintain Sitting

Maintain Standing

Ability to Change Base Of Support

Lying to Sitting

Sitting to Lying

Dynamic Standing Sitting to Standing

Dynamic Standing

Standing to Step Standing

Floor Sitting to Standing

Up Stairs

Down Stairs

Functional Arm Indicators

Balance Arm

Support Arm

Maintain Arm

Functional Component Indicator

Turning Over

Bed mobility

Transfer Bed to Chair/Chair to Bed

Toileting

Functional walking

Wheelchair Mobility

Electric Wheelchair use

Upper Limb Manipulation

During the three validation rounds important changes were made to a large number of the indicators before a consensus was reached. In fact, no consensus was ever reached over the definitions used in the upper limb indicators, although these were included in the

final catalogue (Mawson, 1995). They were however highlighted, as requiring further development but included to stimulate interest and thought. The main changes in the indicators was to achieve two important features:

- * changes that occurred to satisfy the theoretical basis of the Bobath Concept
- * changes that occurred to satisfy the theory of measurements.

The resulting changes are recorded in three flow diagrams included in Appendix 2.3. The significance of the changes that occurred will be identified in the discussion.

9.4.2 Patterns of Change

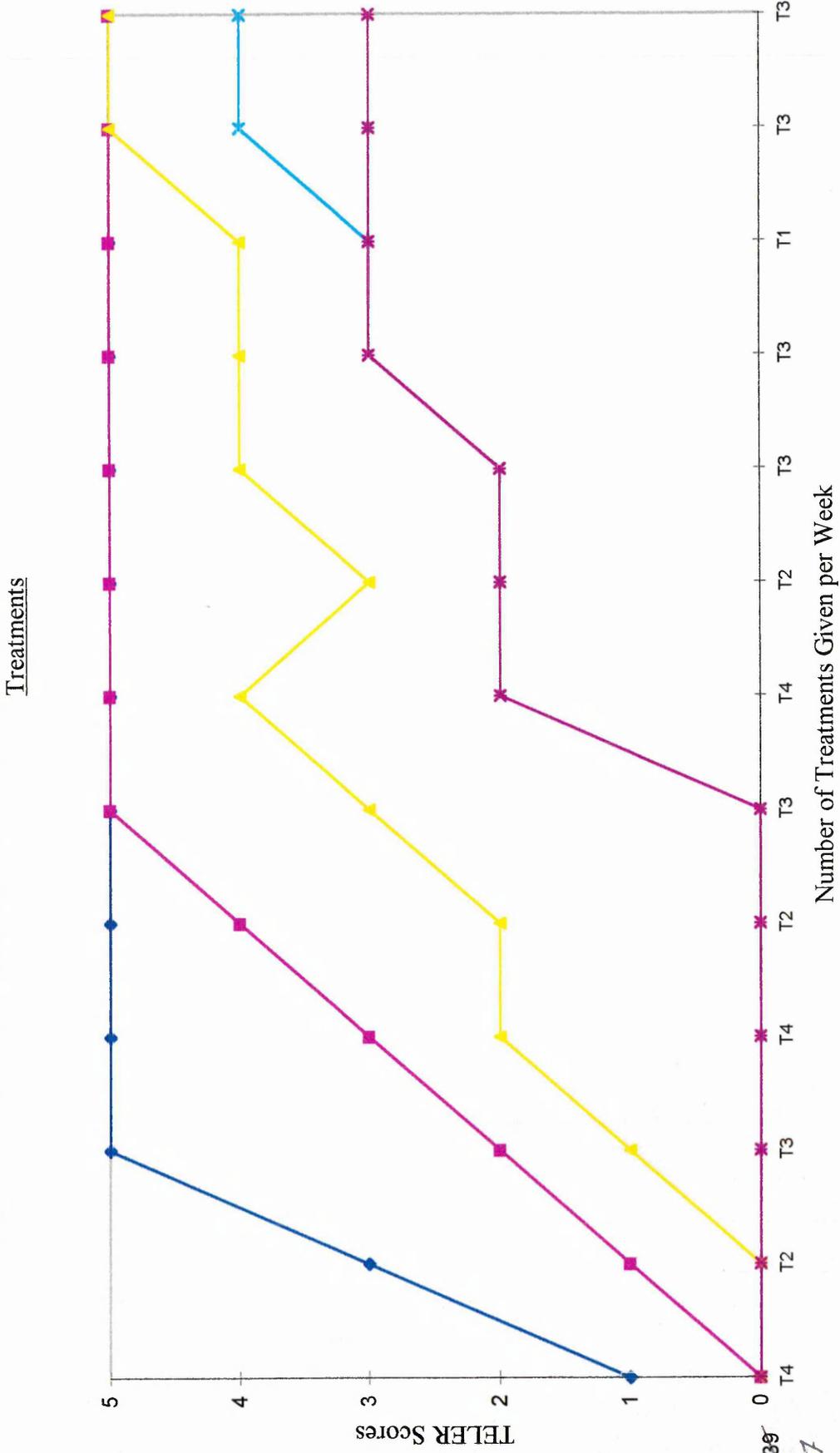
The treatment input and TELER scores were recorded using the TELER documentation system for all of the 41 patients included in this study. It was noted that a distinct pattern of change, or lack of change, was being traced by the TELER indicators. This pattern was described as a '*step and plateau*' pattern as it was characterised by periods of change that appeared to precede the acquisition of another clinically significant code see Graph 1.

Of a total of 192 function tasks recorded, 118 followed a step and plateau pattern, 62% of the total. Appendix 2.2 lists the characteristics of the 41 patients, and includes the frequency of occurrence of this pattern.

A second feature observed in the recorded patterns of change, or lack of change, was the presence of '*fallbacks*' or deteriorations in function ability. An example of this can be seen in graph 1. During the recovery of goal 3, during week 8, there was a '*fallback*' in the score from 4 to 3. Whilst this can obviously not be attributed to any specific event as it occurred in only one indicator, it did suggest that '*fallbacks*' could be recorded and that this might provide valuable information about the underlying neurophysiologic process occurring during physiotherapy treatments.

Graph 1

Pattern of Functional Recovery Observed During Data Collection in Phase II for Patient A1 Receiving 37 Physiotherapy



139
137

9.5 Discussion

Whilst the initial purpose of this second phase was to develop a set of TELER Indicator definitions that had both content and construct validity, a number of important issues emerged during the developmental process.

These can be listed for discussion as follows:

- * Changes that occurred in the indicators to satisfy one of the theories of measurement.
- * Changes that occurred in the indicators to satisfy the theoretical basis of the Bobath Approach.
- * A pattern of change was recorded when the Indicators were used during the implementation of the Bobath Approach for stroke rehabilitation.

9.5.1 Satisfying Measurement Theory

In the initial literature review, the importance of measurement theory to physiotherapist seeking ways to evaluate practice was clearly identified (section 3.3). One of the criteria established in Phase I was that a measure must have logic, that is, it must fulfil the basic principles on which measuring scales are based. This TELER system was chosen specifically because it appeared to fulfil this requirement.

When developing the Function Indicators during Phase II it became apparent that neither clinical or expert knowledge was sufficiently comprehensive to enable the definitions of certain motor tasks if these were to be placed in a hierarchical order. An example of this dilemma arose in the original development of the Indicator of '*rolling*' see Figure 13b. Whilst clinicians had placed the components of rolling into a hierarchy there was some controversy about this and the indicator scores were frequently out of sequence if used in clinical practice.

When critiqued by the BBTA two issues were discussed, one relating to the task, and the other to the clinical steps involved in the task. It was agreed at the consensus meeting that whilst rolling was frequently referred to in treatment programmes, what was actually

required by patients was the more functional skill of *'turning over in bed'*, the components of which were defined and placed in the component indicator structure.

This then fulfilled the patients requirement more fully and placing the components into a component TELER Indicator (Le Roux, 1993, 1995a; Mawson, 1995b) ensured that one of the theories of measuring scale which states that, the codes of the ordinal scale must be in a hierarchical order (Stevens, 1956), could then be satisfied. Once used, a pattern of achievement might be recorded that, once explained, might lead to the development of more formal knowledge. Figure 7 shows the process by which informal knowledge is used in the development of TELER definitions and how, when measurement theory is satisfied, formal knowledge may emerge. The process presented in Figure 7 was undertaken during the present study enabling the development of a theoretical basis for stroke rehabilitation.

9.5.2 Fulfilling the Theoretical Basis of the Bobath Approach

During the validation process, it became apparent that the Indicators were evolving and changing in response to the conceptual basis of the approach being measured. The initial set of indicators were developed in response to patients' needs, the definitions were the result of clinical experiences and were defined by physiotherapists working within the stroke services. When they moved on to the BBTA it was interesting to note, that whilst they were not changed in their fundamental structure, elements of the Indicators were changed to fulfil the needs of the approach. (See Appendix 2.3.)

It can be seen that independent sitting was renamed *'Maintained Sit'* and the definition 0: was changed from *'unable'* to *'unable to be placed'*. Whilst this may not appear to be a very significant change it does, in fact, reflect a fundamental concept of the approach, the importance of *'acceptance of the base of support'*. This phrase frequently used in the literature (Shumway-Cook et al, 1988; Bromley, 1994; Bobath, 1990) and during the teaching process lacked a working definition. However, the development of the indicator had required the therapists to identify what was meant clinically by this term.

It can be seen from the list of clinically significant steps that to be able to maintain sitting (accept base of support) required the patient to be able to take weight through the

supporting surfaces, align the shoulders over the pelvis and keep the hands resting equally on the knees. The theory underlying these steps related to the concept of normal equilibrium requiring normal tone to maintain the centre of mass over the supporting surface achieved by muscle activity around weight bearing joints. As Shumway-Cook suggests, this activity requires a combination of sensory and motor processes to be operational, the Bobath concept stating, that abnormal tone interrupts both processes, thereby interrupting the selective activity required to achieve normal equilibrium.

Similarly, the indicator of Lying and Stand became Maintained Lying and Maintained Stand. The results of this study would suggest that the indicators of '*Maintained*' Sit or Stand are prerequisites for the next stage of recovery. Without the ability to accept a midline position taking weight therefore symmetrically through that supporting surface and maintain equilibrium activity the patients would be unable to move away from or back to the original position, using the same muscle activity to achieve a new or changed base of support. The final list of indicators resulting from the BBTA consensus meeting included this concept of acceptance of base of support, and change the base of support, including the concept of maintenance prior to change. See Figure 13.

Obviously, the working hypothesis that an association exists between the recovery of movement skills required testing. The assumption that the ability to maintain a position against gravity was a prerequisite for the ability to with moving away from and back to that position, became one of the working hypothesis to be tested in Phase III of this study. This concept of prerequisite skills, conflicts with the assumption on which Carr and Shepherd have based their approach to the rehabilitation of stroke patients (Carr and Shepherd, 1987a). This will be discussed in the following chapter.

9.5.3 Operationalising Informal Knowledge

During the developmental process it became apparent that, when defining the clinically significant steps required to achieve the tasks or goals required, a model of recovery was being used that fulfilled the conceptual basis of the approach. As reviewed in the literature, the Bobath Approach had moved towards the rehabilitation of selective trunk activity, regarding trunk activity as central to all normal movements (Bobath, 1981; Davies, 1985, 1990). Mohr (1990) in a teaching document, clearly discusses the

importance of selective trunk activity identifying four muscle groups that include flexion, extension, side flexion elongation and axial rotation. She suggested, that these were hierarchical and that the base of support on which the functional activity occurred, dictated the complexity of the task.

The results of this phase would support the previously identified model (Mohr, 1990) confirming that selective activity in the trunk is essential to the achievement of the identified goals. The hierarchical recovery of this activity appears to be as follows:

FIGURE 11

Model of Selective Trunk Activity Incorporated within the TELER Indicator Definitions

- | |
|---|
| * Flexion of the trunk with a posterior pelvic tilt |
| * Extension of the trunk with an anterior pelvic tilt |
| * Side flexion and elongation of the trunk |
| * Rotation of the trunk |

Other selective activity in the hip, knees and ankles were also identified and there appeared to be a hierarchy within the activity defined. Other researchers have attempted to use aspects of trunk activity to develop a measure of outcome. (Parry, 1983; Carr et al, 1985; Ashburn, 1982). However, previous authors have not identified the individual items that enable '*Maintained Sit*' or '*Dynamic Sit*'. This study has also identified the selective trunk activity required to achieve '*Maintained Stand*' and '*Dynamic stand*'.

In a recent publication, Nieuwboer et al., (1995) also suggested that selective trunk activity and symmetry are components of normal sitting, in their work on the measurement of sitting. However Nieuwboer first identified the abnormalities and problems produced by a stroke by interviewing three experienced neurophysiotherapists and observing five stroke patients. From this, they developed 28 items which '*involved maintaining different positions against gravity and making postural adjustments during voluntary movement*' (Nieuwboer et al., 1995).

This problem based approach resulted in a confusing list of scoring criteria that include abnormal movements and normal movements, plus the fact that trunk selectivity is limited to flexion and extension and lateral elongation with upper limb weight bearing. This combination of activities potentially limits the measurement of true selectivity of trunk activity. Charlton (1995), Gordon (1987) and Horak (1992) clearly suggest, the way forward in understanding motor control lies in the study of action or motor tasks.

The development of the TELER Indicators involved the analysis of motor tasks, the resulting definitions of selective trunk activities being an identification of normal activity, not abnormal responses to a lack of selective activity, (Nieuwboer et al., 1995).

Nieuwboer et al., confirmed the validity of certain definitions of the developed TELER Indicators as she included as relevant the selective activities of flexion and extension in the trunk and elongation with side flexion when the patient lent towards the weight bearing arm. All of the physical functional indicators developed during this phase include these selective activities however they also include the ability to rotate the trunk back towards midline. Without this final element of selective activity, the ability to balance, walk, go up and down stairs or change postures in any way would be almost impossible as rotation around the vertical or horizontal axis occurs during most advanced movement skills.

The importance of this selective trunk activity during the recovery of movement following a stroke has received little attention in the research literature, even though it would appear to be the basis of all activities against gravity (Charlton, 1995). Shumway-Cook et al., (1988) suggest that normal balance or equilibrium which they define as: *'the ability to maintain the centre of body mass over its base of support with minimal postural sway'* is frequently lost following a stroke. Whilst this article is predominantly about standing following a stroke, it can be assumed that this loss of the ability to maintain the centre of mass over the base of support occurs in a variety of other postures such as sitting.

It is interesting that, following the development of the final catalogue of TELER Indicators, the literature supports the conceptualisation of maintenance and changing base of support as a measurement of movement. The findings of this phase are further

supported by Shumway-Cook and Woollacott (1995) as they suggests that, whilst the control of posture and balance involve the integration of sensory and motor processes, it is achieved by the co-ordinated activity of trunk and leg muscles.

Shumway-Cook and Woollacott go on to cite a number of references to lower limb activity and decreased sensory information (Arcan, et al., 1977; Black et al., 1982), she fails however, to discuss or report any research relating to the activity in the trunk during movements, against or towards gravity. Although this study was about the recovery of standing following a stroke, trunk alignment was quantified in terms of lateral sway, this being the transfer of weight laterally using centre of pressure dated from a static force plate.

This data is totally lacking in clinical significance as stroke patients not only require to transfer weight on to the hemiplegic leg, but they also need to maintain alignment or equilibrium over this new base of support. Whilst Shumway-Cook correctly identified the importance of maintenance of equilibrium by trunk activity, she ignores this concept when trying to measure the rehabilitation of standing in stroke patients.

This is an extremely important area of stroke rehabilitation as it might be suggested that the ability to transfer weight on to either leg whilst maintaining a new postural alignment is, a prerequisite for stepping prior to walking. This assumption will be tested during the third phase of this study, using the validated Physical Function Indicator of Dynamic Stand and Stand-Step.

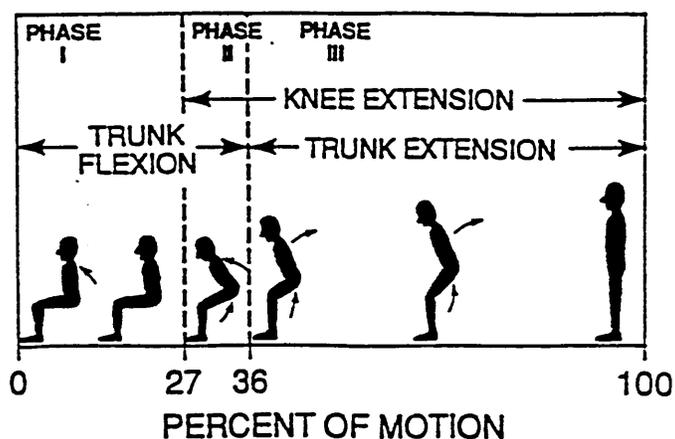
Having defined the selective activity of the trunk as items within the TELER Indicators, these could then be used to investigate the relationship between the recovery of trunk activity in different motor tasks. Of particular interest would be the association between the maintenance of a posture and movement from one posture or base of support to another. This might provide evidence of the link between hierarchical movements within the trunk and the size of the base of support, suggested by Mohr (1990) in her teaching document on the management of the trunk.

9.5.4 Validating the TELER Definitions: Kinematic Analysis

If the indicators developed during this phase were to be used to provide this evidence, the biomechanical literature must be reviewed to establish, whether the definitions provided by the clinicians in Phase 11 are supported by quantitative analysis of movement. Millington (1992) using kinematic analysis of ten elderly subjects, identified three phases of the movement of Sit to Stand. See Figure 14.

FIGURE 14

Three Phases of Sit to Stand Motion Defined from Kinematic Analysis



From: Millington (1992)

Whilst this analysis does agree with the clinical definitions of Sit to Stand in the TELER catalogue, there are some discrepancies between the findings of Millington and those of this study. The data provided by Millington appears to suggest, that the starting position for Sit to Stand is 84 degrees of extension at the knee progressing to approximately five degrees in standing. Figure 14 also suggesting the movement begins with approx. 90 degrees at the knee moving to extension. The clinical definitions of Sit to Stand suggested, that the feet were required to be placed behind the knee towards the centre of the mass. If this clinical step was not achieved, the patient was unable to lift the bottom from the chair.

Millington then continues by describing trunk flexion as being the first '*discernible*' activity however this would appear to, in fact, be hip flexion. During the development of the TELER Indicators, the position of the pelvis as the start of the movement was

important as this was found to be frequently in a posterior tilt requiring to move into an anterior tilt, before the flexion of the hip took place. These findings were supported by Nuzik et al (1986) who used kinematic analysis of Sit to Stand in a group of 38 women and 17 men. In this study Nuzik found that the pelvis was initially, posterior moving 26 degrees towards and 12 degrees past the vertical axis during the first half of the movement. It was also noted that during the second half of the cycle the pelvic position reversed to achieve the standing position.

Whilst not identifying this important component of Sit to Stand the results of Millington's electromyographic (EMG) data did support the results of this study, and that of Nuzik's as it was recorded that Erector Spinae activity was '*consistently the first muscle recruited (14.6% of motion) for all trials and subjects*'.

Using both kinematic and EMG data to analyse Sit to Stand the findings of Vander Linden et al., (1994) also support the clinical definitions and observations of Phase 11 Sit to Stand Indicator. The results of this study, in recording the activity of Erector Spinae following flexion of the hip suggest, that once the centre of mass has been moved forward by the hip flexion, the Erector Spinae activity produces extension in the lumbar spine in order to maintain the centre of gravity over the new base of support prior to the extension phase in the hips, knees and ankles.

A second indicator reviewed for its validity in the biomechanical literature, was the indicator of '*Stand to Step*' used for either the left or right leg as required, usually prior to the '*Functional Walking*' Indicator. Much of the biomechanical literature relates to the initiation of stepping as being the result of the Centre of Gravity (CoG) moving forwards and out of the base of support (Mann et al., 1979; Winter, 1987; Shimba, 1984).

However, an important clinical step identified during this study that occurs prior to the forward movement of the CoG is the lateral transfer of weight necessary to enable the unilaterally forward propulsion by a partial weight bearing foot, code 1 of the TELER Indicator. Interestingly although the significance of this important shift is not discussed, it is supported by Winter et al., (1990) in an outline of gait, he cites his earlier work stating: '*during that time period one limb is pushing off with considerable force whilst the other limb is accepting the full weight of the body*'. The literature fails to identify or

discuss the resulting biomechanical principles of changing base of support, that is the need to maintain the CoG over the new base. When analysing the muscle activity required to achieve this weight transfer, it is quite clear that the trunk side flexors and hip abductors/extensors will be crucial. Both of these steps are recorded in the TELER Indicator of '*Dynamic Stand*'.

Whilst the evidence is available in the quantitative analysis of movements supporting the clinically developed indicators, the significance of certain components are ignored. The importance of being able to transfer weight, and momentarily balance on the weight bearing leg, the importance of anterior tilt prior to the movement of Sit to Stand are not identified or even discussed. For stroke patients these can be crucial factors in the recovery of normal movement and functions, the ultimate goal of the rehabilitation process.

This review of two clinically developed TELER Indicators, serves a number of purposes, one to establish the validity of clinical observations and knowledge which was supported by sophisticated quantitative data and secondly, to invalidate the results of apparently scientific data.

Neither Millington or Vander Linden et al., (1994) identified the initiation of anterior tilt prior to hip flexion or lumbar extension, however, if a patient cannot bring the pelvis into a vertical position, taking their feet behind their knees, they will not be able to achieve the outcome of Sit to Stand. Both factors missed in the '*scientific*' analysis of the last two researchers and clearly identified in the TELER Indicator definitions. Whilst this trunk activity is recorded in the biomechanical analysis of movement, its significance is poorly identified.

9.5.5 Pattern of Recovery

The findings of Phase 11 would indicate that a '*Step and Plateau*' pattern of recovery occurs in the ability to achieve selective trunk activity during stroke rehabilitation. In fact this pattern, was traced in 45% of the indicators scored. As reviewed in the initial chapters, this was first identified by Dombovy and Bach-y-Rita (1988) when they cited Twitchells (1951) description of plateaus in his study of 121 stroke patients. However,

this reference relates to a plateau at the end of the recovery phase. Bach-y-Rita and Balliet (1981) first introduced the idea of plateaus between phases of acquisition and it is this pattern that has been traced in 45% of functional goals during Phase 11.

The pattern recorded in this study is quite different from that recorded by Partridge et al., (1987, 1993) in which the results of their study of 700 stroke patients suggested a linear or curving recovery pattern, that they state: *'may be a useful way of monitoring quality of care in the physiotherapy treatment and management of a number of conditions involving physical disability'* (Partridge and Morris, 1993).

Whilst this study was very extensive and received national recognition, it is flawed in two respects. Firstly, a dichotomous score was recorded for *'Gross Body Movements'* that included stepping, lying to sitting and transfer. In collecting, able or unable to achieve, data the researchers may have failed to record clinically significant steps required to achieve these gross body movements. Secondly, when the data was subsequently averaged to provide a mean score, the resulting linear curved pattern of recovery was inevitable.

As there was little evidence in the literature of investigations into the plateauing concept (Acheson Cooper and Saarinen-Rahikke, 1992) identified in this study the purpose of the third phase was to use the indicators developed in Phase 11 to establish the characteristics of the plateaus as they occurred in the recovery of function activities during stroke rehabilitation by Bobath trained physiotherapists.

9.6 Summary

During the development of the TELER Indicator definitions a number of important characteristics were revealed regarding the current clinical practice of Bobath Physiotherapists.

Evidence was provided that the Bobath Physiotherapists use a model of hierarchical trunk selectivity as a foundation for the recovery of function. Whilst this is not new knowledge, the integration of this taught model (Davis, 1985; Bohman, 1987; Mohr, 1990; Lennon, 1996) into a measuring system has resulted in the observation of a pattern

of recovery that may provide new evidence of the mechanisms underpinning stroke rehabilitation. Further investigation of this pattern, may provide evidence which will enable the development of a theoretical basis for stroke rehabilitation.

It became apparent that the model was initially based on automatic responses to a changing base of support or an alteration of the centre of mass, this was a foundation for the achievement of volitional tasks identified as the named TELER Indicator.

CHAPTER 10

PHASE III CONSTRUCT AND CONCURRENT VALIDITY: TESTING A WORKING HYPOTHESIS.

10.1 Introduction

The TELER concept is based on the use of knowledge to define, clinically significant outcomes as the points of the measuring scale, the TELER indicator. The system is also based on the '*given*' that physiotherapy treatment is patient centred and patient oriented. During the development of the catalogue of physical function indicators (Mawson, 1995b), Bobath trained clinicians and experts within the area of the Bobath Approach were used to establish the content or '*face*' validity of patient negotiated functional goals that became the outcome indicators.

As discussed in Chapter 9, the developmental processes resulted in certain changes to the indicators by experts within the approach. These changes in conjunction with the clinical input by stroke physiotherapists ensured that the indicators fulfilled the conceptual basis of the Bobath Approach. That is, that the measure was sensitive enough to record the recovery of normal movement in hierarchical clinical steps. The items within certain indicators were confirmed by quantitative movement analysis satisfying some aspects of construct validity (Wade, 1992b; Herbert, 1990). It became apparent, during Phase 11 that the measurement of recovery during the implementation of the Bobath concept was based on a number of assumptions. These assumptions or '*givens*' are as follows:

- * the recovery of functional goals occurred in clinically significant steps
- * these clinically significant steps towards the achievement of a functional goal involved the recovery of selective activity of the trunk
- * selective activity of the trunk recovered in a hierarchical order and the ability to achieve selective trunk activity in standing, was dependent on the ability to achieve selective trunk activities in sitting

- * the ability to achieve postural alignment was a prerequisite for normal movement and normal balance
- * the ability to maintain postural alignment was dependent on the recovery of selective trunk activity and the ability to perceive midline
- * the recovery of the clinically significant steps was characterised by no change known as consolidation, and change known as acquisition, and by occasional '*fallbacks*' in the recovery of clinically significant steps required to achieve a functional goal
- * the CNS appeared to change in response to intrinsic or extrinsic environmental information (Held et al., 1985; Rosenzweig et al., 1980; Lee, 1978)
- * change within the structure of the CNS could produce adaptive or maladaptive motor behaviours
- * the ability to maintain postural alignment over a base of support was a prerequisite for normal movement to another base of support
- * the ability to achieve the recovery of motor tasks appeared to be a learning process that occurs over clinically significant time periods (Ebbighaus, 1885; Shumway-Cook and Woollacott, 1995; Kupferman, 1991; Kandel, 1989)
- * selective trunk activity and selective limb activity are interdependent during normal balanced movement, as are the neurological and musculo skeletal systems involved in producing normal balanced movement
- * interaction with the environment, intrinsic or extrinsic has a direct effect on the ability to perform a functional task

From these assumptions or '*givens*' about the recovery of function during the implementation of the Bobath Approach, a number of working hypothesis were

developed and tested during this phase of the study. Wade (1992b) suggests that if the results obtained from a measure concur with the results predicted '*from the underlying theoretical model*' then the measure will have construct validity.

Construct validity is based on theoretical knowledge, however the earlier presentation regarding the theoretical basis of the Bobath Approach highlighted a lack of documented evidence about the present state of this physiotherapy method. Literature available to date, might suggest that the Bobath Approach (Bobath, 1990) is grounded in the earlier neurophysiological theories of motor control, (McGlown, 1990; Ashburn, 1995) lacking an integration of more recent scientific evidence from the fields of cognition, behaviour and biomechanics. Testing the working hypothesis developed from the assumptions listed, should therefore, not only result in the development of theoretical knowledge, but also establish the construct validity of the definitions of the TELER indicators.

Remembering back to the original presentation of models of stroke rehabilitation, an approach developed by Carr and Shepherd (1985, 1989, 1987a,b) and known as the Motor Relearning Programme appeared, unlike the Bobath Approach, to have integrated behavioural (Carr and Shepherd, 1989; Johnson, 1984; Newell and Rosenbloom, 1981; Carr and Shepherd, 1994b) and biomechanical (Canning et al., 1985) knowledge, within their treatment strategies. Furthermore it became apparent when reviewing the literature, that antagonisms had developed between protagonists of the two approaches (Carr and Shepherd, 1994a,b) and it was felt that this could potentially limit the development of stroke rehabilitation strategies in the future.

When analysed, the assumptions on which the Motor Relearning Programme is based, resemble those of the evolving Bobath Approach identified during the development of the TELER indicators. Whilst Carr and Shepherd suggest, in their book on the Motor Relearning Programme (1987a, b) that their assumptions are: '*in marked contrast to the assumptions underlying much current physiotherapy practice.*' in comparison, this would appear not to be the case. See Figure 15.

FIGURE 15

The Major Assumptions on Which the Motor Relearning Programme is Based

1. Regaining the ability to perform motor tasks such as walking and standing up involves a '*learning*' process.
2. Motor control is exercised in both anticipatory and ongoing modes and that postural adjustments and focal limb movements are interrelated.
3. Control of a specific motor task can best be regained by practice of that specific motor task, and that such motor tasks need to be practised in their various environmental contexts.
4. Sensory input related to motor tasks help to modulate actions.

Adapted from Carr and Shepherd (1987a)

Whilst the mechanism for achieving the rehabilitation of stroke patients may differ, the assumptions are remarkably similar. One basic difference, between the two approaches however relates to the following statement by Carr and Shepherd:

'The retraining of balance in sitting and standing require that the patient experiences these positions. That is, he will not regain the ability to stand until he is in a standing position. It should be noted that the regaining of balance in sitting is not a prerequisite for standing. The alignment of the body segments to each other in sitting and standing is different and the biomechanical (and therefore the muscle activity) are also different It is important to recognise the fact that the patient will only regain good control over balance if he practises in that position.'

Carr and Shepherd (1987a)

It can quite clearly be seen that this is in conflict with the assumptions previously identified, that sitting balance and alignment are prerequisites for standing balance and standing alignment. The clinically significant outcomes of the TELER indicators being the selective trunk and girdle activity required to achieve balanced sitting or standing. During the developmental phase it became apparent, that the trunk muscle activity

required to achieve '*dynamic sitting balance*' and '*dynamic standing balance*' were the same. It also appeared that the ability to achieve synergic muscle control on a large base of support was a prerequisite for control on a smaller base of support.

The Motor Assessment Scale (MAS) developed by Carr and Shepherd et al., (1985) to measure the functional recovery of stroke patients, includes items of balanced sitting that are theoretically task orientated (Poole and Whitney, 1988), standing being incorporated within the walking item of the MAS. A number of authors (Wade DT, 1992b; Pogar and Thomas, 1991) suggest, that the way to establish the concurrent validity of a measure is to test it against a '*gold standard*'. This is an unusual suggestion, if a gold standard already exists, there should be no need to develop a new one. In the area of neurological rehabilitation, measurement for physiotherapists is complicated by a lack of consensus regarding the theoretical basis of stroke intervention. Whilst the MAS apparently measures the recovery of function following a stroke, it is difficult to assess whether the definitions of the items included fulfil the requirement of measurement theory. Furthermore, the theoretical assumptions on which it is based, are in conflict with the assumptions regarding the recovery of function on which the TELER indicator definitions, developed in this study, are based. A further issue relating to the use of a '*gold standard*' revolves around the responsiveness of a measure. A previously developed and frequently used measure may be accepted as the gold standard, but does it truly reflect important or clinically significant change?

The reason therefore why the MAS was chosen for scoring patients in conjunction with the TELER indicators in this phase are two fold. Firstly, to assess the responsiveness of both measures to trace changes in functional recovery following a stroke and secondly, the scores would be correlated to establish whether the two measures are in fact measuring the same theoretical model of stroke rehabilitation. If the results concur then both have construct validity, but only if the MAS like the TELER method, fulfils the requirements of measurement theory (section 3.3). If certain assumptions can be tested and evidence of effective treatment can be provided, the process of developing a theoretical basis for stroke rehabilitation will be facilitated

The TELER indicator, as presented earlier, fulfils the theory of measurement being based on clinical significance and therefore has both predictive and construct validity, if the

definition are based on sound theoretical knowledge. However, it has been suggested that the theoretical basis of the Bobath Approach is poorly documented and the purpose of this phase of the study was, therefore, three fold. Firstly, to establish the construct validity of the definitions of the points on the TELER indicators developed during the second phase of the study. Secondly, using the information obtained during the treatment sessions, to establish the characteristics of effective intervention and thirdly, to test certain assumptions, redefined as working hypothesis, on which the Bobath Approach appears to be based.

As a measure of functional recovery, the MAS developed by Carr and Shepherd et al., (1985), would be used in conjunction with the TELER indicators to establish the theoretical basis of the Bobath Approach and the responsiveness of both measures to trace patterns of change in functional status over time.

To achieve these objectives a number of aims were identified as follows:

- * To recruit ten stroke units with a minimum of two Bobath physiotherapists willing to participate in the validation study.
- * To train the physiotherapists in the use of the TELER system and the MAS if necessary.
- * Score patients for a 12 month period on the MAS and the TELER indicators using the TELER documentation system.
- * Use the TELER indicators and MAS to trace the pattern of change, or lack of change, in the recovery of motor tasks following a stroke of vascular origin.
- * Analyse the information to establish the similarities and difference between the scores.
- * Analyse the information to test the assumptions on which the Bobath Approach is based.

To achieve these objectives the following assumptions, on which the Bobath Approach appears to be based, redefined as hypothesis, will be tested (Acheson-Cooper and Saarinen-Rahikka, 1984; Van Slant, 1988):

- * An association exists between the TELER indicators of Maintained sitting, Dynamic sitting and site of the lesion (NIH unilateral spatial neglect)
- * The ability to achieve maintained sitting is a prerequisite for dynamic sitting and that this is a prerequisite for maintain standing and dynamic standing therefore, there is a dependence between the definitions of the named indicators.
- * The recovery of selective trunk activity is hierarchical within a given base of support.
- * The ability to recover selective trunk activity on a smaller base of support is dependent on the recovery of selective trunk activity on a larger base of support therefore, an association exists between the different bases of support denoted by the indicators of sitting and standing.
- * There are plateaus of no change in the ability to achieve recovery of motor tasks during treatment

In order to fulfil the identified objectives in this phase, the following approach was used.

10.2 Approach

As the fundamental purpose of this study was to identify the characteristics of effective stroke physiotherapy, the information obtained had to be in a clinical environment, not in a structured research format. The earlier review of the Bobath Approach identified that the problem for physiotherapists, using the approach as being two fold. The first problem regarding a lack of appropriate measuring system having been addressed during Phase 11. The second problem relates to the nature of the approach in that it is non prescriptive and standardised treatment protocols are unrealistic. Treatment input is dynamic and changes in response to the patient's changing neuromuscular presentation.

This concept has been clearly documented by Riddoch and Lennon (1994) in their suggestion that: *'single case design maybe the best way of achieving 'tailored'*

treatment'. They go further, by suggesting that effective treatment as demonstrated in one case study must be reproduced in a number of individuals to build up a body of evidence regarding effect.

The single-subject method of evaluating practise has received considerable attention in the literature (Sunderland, 1990; Sims, 1994; Cambell, 1988; Robertson and Lee, 1994) partly because of the ethical issues and resource implications that a lack of effectiveness research might produce (Riddoch, 1991). Much of the controversy surrounding this method of evaluation relates to the scientific credibility of the method in physiotherapy (Bithell, 1994) and its ability to provide evidence of attribution for the individual, as opposed to the aggregated data of the group study (Martin, 1977). Simms (1994) identifies this group dilemma quite clearly when he quotes the words of Barlow and Hersen (1984):

'if we ignore differences among individuals and simply average them into a group mean, it will be more difficult to estimate the effects on the next individual, or 'generalise' the results.'

Robertson and Lee (1994) in a very interesting article on the misconceptions of single subject design in physiotherapy, not only clarify some of the issues related to the evaluation of practice, but also suggest certain concepts relevant to both the TELER system of evaluation and this particular study.

Perhaps the most important concept presented by Robertson and Lee relates to the debate about *'scientific credibility'*. Bithell (1994) whilst, supporting the use of single subject design in clinical practice *'increase our understanding of the ways in which physiotherapy interacts with normal healing processes,'* suggests that the only way to demonstrate the effectiveness of physiotherapy is by using sample group studies. She continues to state, that using a series of single case studies is not appropriate and that the results produced are unscientific and lack credibility, with whom, she fails to state.

Robertson and Lee on the other hand, approach the debate from another perspective, that is the questioned usefulness of information provided in the so called scientific studies. They suggest, that considerable concern exists regarding the use of group

comparison and inferential statistics (Huxley, 1986; French, 1988; Mixon, 1990) and that the important issue of research methods in physiotherapy relates to the contribution made to evaluating and improving clinical practice.

The fundamental concept of this argument revolves around the unit of measurement being studied. Robertson and Lee state that traditional research methods classify, count and average across groups of human beings. The emphasis being the ability to generalise from a sample. This assumption that the individual is the case to be counted, in research into an aspect of that individual, is known as '*individualism*' and has according to Robertson and Lee, a number of critics (Sampson, 1988; Sarason, 1981). They continue, by making the valid point that in physiotherapy practice it is not the individual, but the units of that individual that require methods of evaluation:

'If physiotherapy is viewed technically, then its single cases are not the individual clients, but rather the particular aspects of people bodies or performances that are counted, classified, and treated and about which knowledge needs to be accumulated.'

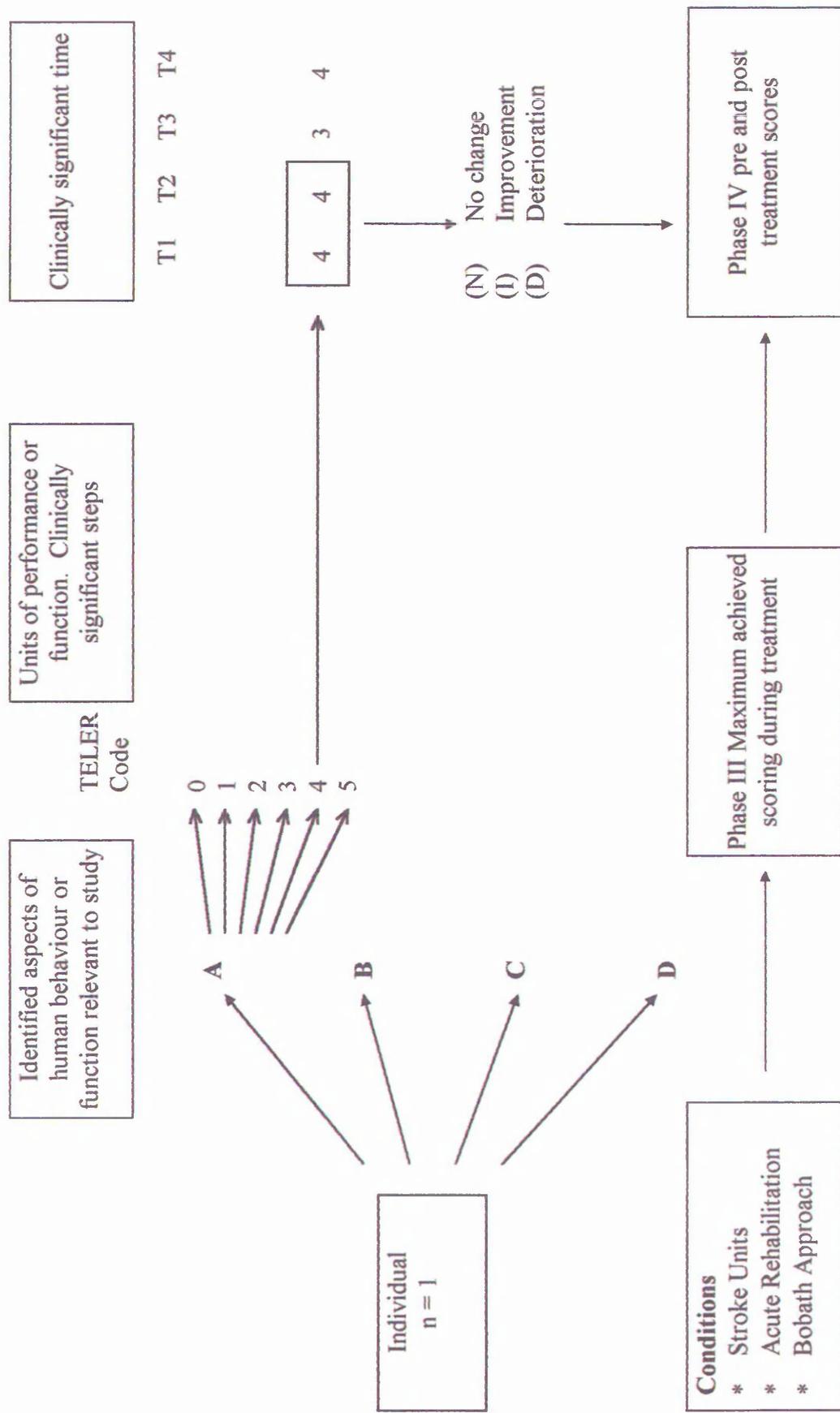
Robertson and Lee (1994)

A further important point developed by Robertson and Lee relates to the concept of change over time. As they suggest, traditional methods frequently fail to pay attention to the need to count or classify units of measurement over a clinically significant time periods, simply enabling the researcher to state whether on average the independent variable has a greater effect on a group of patients than would be expected through chance alone. Whilst the single case $n=1$ involves a small number of units, if the behaviour or function of an individual, the aspect of interest to the evaluator, is defined into clinically significant units, these can provide a far larger number of '*data points*'.

Ottenbacher (1986) suggested a minimum number of 7 data points and Sunderland (1990) 10, if statistical analysis is to be used. Bithell suggests that it is often difficult to collect these numbers if $n=1$ =unit of measurement. However, if Robertson and Lee's concept of units of interest over time are used, then a far larger number of data points could be collected which would be of greater clinical value to the physiotherapist.

FIGURE 16

Single Case Study Evaluation
Researching Physiotherapy Practice: TELER the Form that Provides the Count



Whilst Robertson and Lee were probably unaware of the TELER method of single case study evaluation, their argument and conceptual presentation of measuring physiotherapy intervention totally supports the system developed by Le Roux (1993). As presented in Chapter 8, the basic assumptions of the system is that the purpose of physiotherapy is to induce or prevent change, and that change occurs in clinically significant steps over clinically significant time period. These clinically significant steps are the units of measurement described by Robertson and Lee, they are traced over time in a variety of settings providing the evaluator with large numbers of data points that can be used to provide evidence of induced or random change.

The individual of interest in this study was the stroke patient, the physiotherapy process to be investigated being the Bobath Approach, the behaviour to be studied was motor function, this becoming the unit of interest (Robertson and Lee, 1994). As Riddoch (1994) suggests, little is often known about the performance or task of interest. The purpose of the second phase of this study, was to identify the units or definitions of the motor tasks. These clinically significant steps based on informal knowledge (Le Roux, 1993; 1995a), that is knowledge that comes from clinical experience, were validated by expert clinicians, certain indicators being supported by quantitative research data. In this way they became the units to be recorded in the third phase of this study. See Figure 16.

Of particular interest in this phase was the association between the achievements of units within a motor task, and between motor tasks themselves. Information was also required regarding the pattern of change recorded in the achievement of the units within the motor tasks to establish whether periods of no change or plateaus occurred during the recovery process.

It is interesting that Bithell (1994) suggests, that in single study design there are *'threats to the internal validity and reliability arising from heavy reliance upon frequent measures'* She continues, by stating that learning may occur as the *'testing'* alters the behaviour. The fundamental purpose of the Bobath Approach is to induce relearning of motor tasks, it is this learning process that must be quantified, not controlled out of the equation. It might be hypothesised that the consolidation and acquisition pattern of change recorded in the second phase, were in fact, a quantification of the theoretical learning process. This will be investigated and discussed in Phase IV.

The single case study design would therefore, be used in the third phase of this study using the identified and the validated units of measurement, the clinically significant codes of the TELER Physical Function indicators to investigate the recovery of motor function in stroke patients admitted to stroke units for rehabilitation.

10.3 Method

Ten stroke units each, with a minimum of two Bobath trained physiotherapists were recruited throughout the UK using the TELER network of users and the Association of Physiotherapists with a Special Interest in Neurology (ACPIN). Any new patient admitted to the unit over a twelve month period, who fulfilled the inclusion and exclusion criteria identified for the previous study, were included.

10.3.1 Procedure for New Patients

- * Patients were assessed subjectively to determine the goals for treatment.
- * Patients were assessed objectively to determine the achievability of short and long term goals.
- * Patients were scored on the Rankin handicap scale and the National Institute stroke scale, during the routine assessment process.
- * Patients' problem list was documented.
- * Using the TELER catalogue, Physical Function Indicators were selected that were appropriate to the requirements of the individual patient. If none of the indicators were suitable, physiotherapists were instructed to develop new indicators.
- * A minimum of three indicators were chosen at the beginning of rehabilitation, however these were added to as the patient required.
- * The maximum achievement during the treatment session was scored by the treating physiotherapist.
- * To ensure standardisation of measurement, a series of clinical standards were included with the documentation and protocol for this phase. See Appendix 3.1.

10.3.2 Scoring

To avoid the possibility of therapist bias, and to provide evidence of interrater reliability, an independent scorer observed all treatments and scored the patient independently on a separate TELER Indicator form.(See Appendix 3.7.) All patients were scored on the Barthel Index in accordance with Royal College of Physicians guidelines (1989). (See Appendix 3.5.)

Patients were also scored on the most appropriate item in the MAS by the independent therapist. Guidelines for the use of this and the forms used in this phase can be found in Appendix 3.3, 3.4, 3.4.1. No patient was scored on all the items in the MAS or on all the indicators in the TELER catalogue, as the purpose of this study was to investigate the recovery of motor function during clinical practice, and only those outcome indicators relevant to the patient were recorded. The individual units of interest being standardised by using core movement indicators, the ability to achieve the items being recorded over time.

Treatment input was documented during the episode of care for each patient however, this was in no way standardised for each patient in accordance with the concepts of neurological physiotherapy intervention.

10.4 Analysis

Whilst Robertson and Lee suggested a concept of evaluation, they did not suggest how this information could be recorded. Le Roux (1993) in developing a concept of evaluation, also developed a method for analysing the patterns of change, or lack of change, recorded.

The TELER system is based on the concept of random change with equal probabilities, the unit of measurement being clinically significant change or lack of change, providing three categories of either improvement (I), no change (NC) or deterioration (D). The assumption being that the clinically significant change defined by the clinician is based, on either formal or informal knowledge. The probability of patterns or profiles obtained

being chance, or random occurrences can be calculated in a number of ways, depending on both the information required and the level of independence of the data points used.

For example, to estimate the probability of a particular pattern such as a 'fallback' or D, being a chance occurrence in a group of independent subjects at a given time point, the following mathematical method would be used:

Let 1 fallback :code 5 denote one subject deteriorating from code 5

Let 1 fallback :any denote one subject deteriorating from any code other than 5 then :

$$P(1 \text{ fallback : code 5}) = 0.5$$

$$P(1 \text{ fallback : any}) = 0.333$$

Setting a significance level of 3% that is if $p < 0.03$ it can be concluded that, the deterioration observed is not the result of random events, but attributable to a variable or variables affecting the patient. However to be able to reject the null hypothesis in this way and provide evidence of attribution, 6 patients are required as follows:

$$P(1 \text{ fallback : code 5 for 2 subjects}) = (0.5)^2 0.25$$

$$P(1 \text{ fallback: code 5 for 3 subjects}) = (0.5)^3 0.125$$

$$P(1 \text{ fallback: code 5 for 4 subjects}) = (0.5)^4 0.0625$$

$$P(1 \text{ fallback : code 5 for 5 subjects}) = (0.5)^5 0.03125$$

$$P(1 \text{ fallback : code 5 for 6 subjects}) = (0.5)^6 0.015625 \quad P < 0.025$$

When the fallback occurs from any other code the number of subjects required to be able to reject the null hypothesis and provide evidence of attribution is 4 as follows :

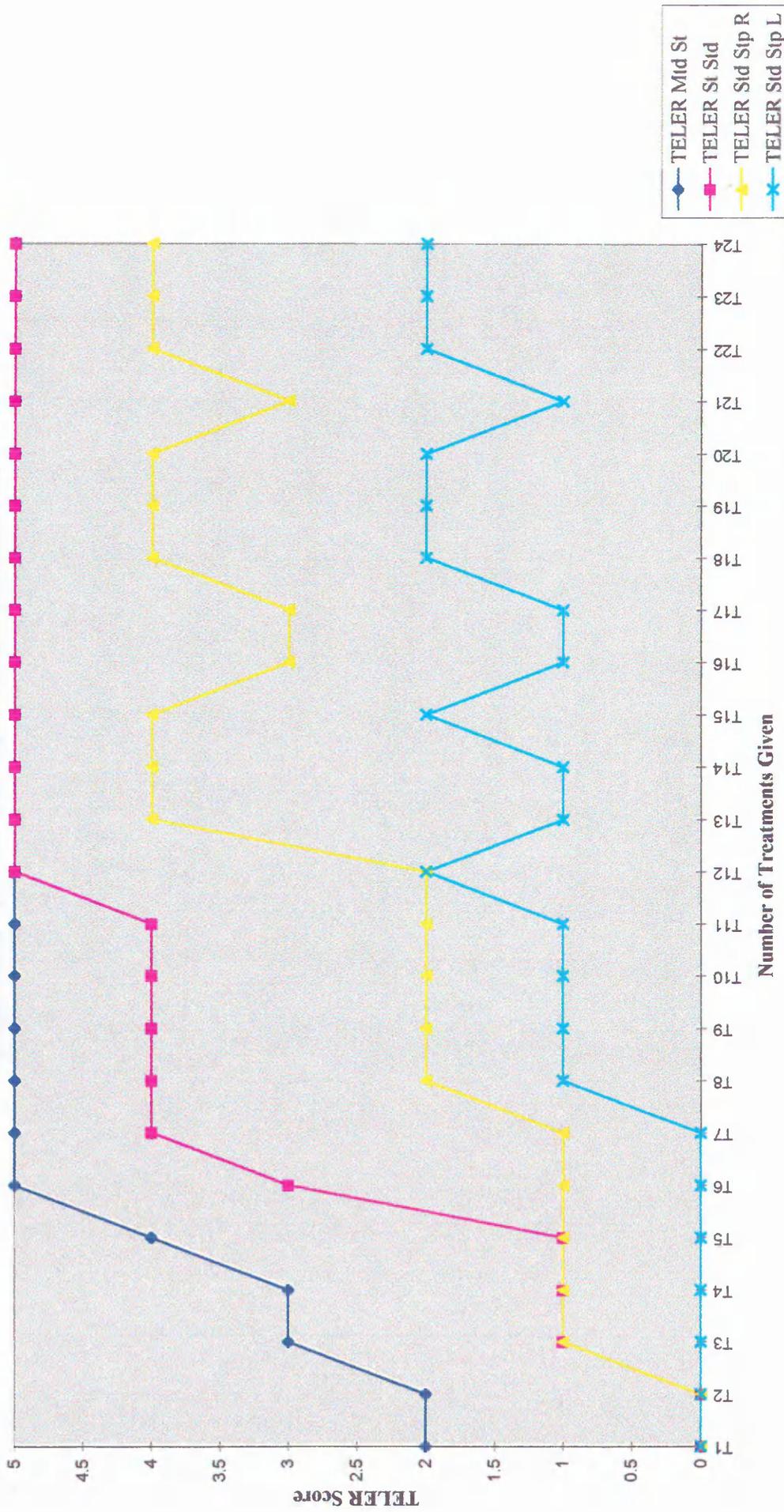
$$P(1 \text{ fallback : any for 2 subjects}) = (0.333)^2 0.1109$$

$$P(1 \text{ fallback: any for 3 subjects}) = (0.333)^3 0.0369$$

$$P(1 \text{ fallback: any for 4 subjects}) = (0.333)^4 0.0123 \quad P < 0.025$$

Theoretically, if the data points are independent, the definitions valid and the scores reliable, the fall backs traced using this example are not random or chance deterioration, but attributable to something such as development of a DVT or to a change in physiotherapy input. Whilst this method of estimating probabilities does not prove cause

Recovery Pattern Observed During 24 Physiotherapy Treatment Sessions Demonstrating 'Fallbacks' in Motor Skill Acquisition that Appeared to be Associated with Weekend Breaks in Physiotherapy



and effect in a clinical setting, it provides evidence of attribution that can be investigated further or studied in a more controlled research setting.

During the second phase of this study, it was noted that within the recovery process there were '*fallbacks*' (D) in the ability to relearn specific components of the required motor skill. Graph 2 shows the recovery pattern recorded during the rehabilitation of patient RH2. '*Fallbacks*' or deteriorations in ability were recorded in 3 of the 4 TELER Indicators: Sit to Stand, Stand to Step Left Leg and Stand to Step Right Leg. Further analysis of the timing of these fallbacks, demonstrated that they appeared to occur after weekend breaks in treatment. Therefore a working hypothesis was added to those previously identified as follows:

- an association exists between the '*fallbacks*' observed during the recovery of motor function and weekends periods when patients do not receive physiotherapy intervention.

To test the working hypothesis stated, the patterns of change traced during this study, were analysed for either one subject using groups of indicators where these were deemed to be independent measures, or for specific indicators within subject groups. Contingency tables were used with improvement (I), no change (NC) or deterioration (D) being the ordinal categories. The Chi square test for goodness of fit was used to determine, whether the pattern recorded was statistically significant, and therefore attributable, or a random occurrence. When using the Chi square test a confidence level of 95% was used, that is if $p < 0.05$ the null hypothesis is rejected, and the alternate hypothesis that the observed association or dependence between variables exists is accepted.

To establish whether both the TELER indicators and the MAS were measuring the recovery of motor function, the differences between scores achieved on the TELER indicators and comparable MAS indicators were analysed both clinically and statistically. As both measures are based on ordinal scales, the distance between points not being uniform, a rank correlation was used to analyse the differences between scores. This method of analysis would not establish which of the measures was more sensitive to change that is I, D, NC, therefore a contingency table was used and the observed

patterns analysis as previously described, using the Chi square test with a confidence level of 95%.

10.5 Results

10.5.1 Demographic Data

A total of 29 patients were included in this phase of the study, a table containing the demographic and clinical data from these patients is included in appendix 3.8. A summary of this information is presented in table 17.

TABLE 17

Summary of Demo-graphic and Clinical Data for Patients included in Phase III

n=29

Mean Age	Range	Gender	Location of CVA	Average Rankin Score
60	42-75	22 Male 6 Female 1 NA	15 Left 13 Right 1 NA	4

NA Data not available

10.5.2 Handicap and Site of CVA

Numerous studies have investigated the relationship between the hemisphere involved following a stroke, and the level of independence at discharge, many agreeing that there is no relationship between the two (Jongbloed, 1986; Boureston, 1967; Wade et al., 1984; Lincoln et al., 1989). During this study, data was obtained regarding the hemisphere involved, however patients were only scored on the Rankin handicap scale at initial assessment. This data was analysed however, to establish whether an association existed between the initial handicap score and the site of the lesion at the commencement

of physiotherapy to determine, whether the site of the lesion might have an affect on the potential prognosis for recovery. The reason being that an investigation into the characteristics of functional recovery during physiotherapy intervention was one of the aims of this study. Data was analysed as follows for a total of 69 patients included in Phase I, Phase III and Phase IV:

i) Observed Number of Involved Hemispheres,

Rankin Score	L	R	Total
2	1	1	2
3	6	6	12
4	15	17	32
5	12	11	23
Total	34	35	69

ii) The null hypothesis being that there is no association between the site of the CVA and the level of handicap as scored on the Rankin Handicap Score.

iii) The alternate hypothesis being that there is an association between the site of the CVA and the level of handicap as scored on the Rankin Handicap Score. Calculations included in Appendix 3.9.1.

iv) Calculated $\chi^2 = 0.1551$

v) Degrees of freedom = $(4-1) \times (2-1) = 3$

vi) Tabulated $\chi^2 = 7.815$

vii) Since calculated $\chi^2 <$ tabulated χ^2 the null hypothesis is accepted and the alternate hypothesis rejected.

viii) Hence:

No statistically significant association was found between the site of the CVA and the level of Handicap scored on the Rankin scale at the commencement of the episode of care on the stroke unit.

Whilst these results relate to an association between the initial handicap level and the site of the CVA as opposed to the level at discharge, they do appear to support the findings of Jongbloed (1986), Boureston (1967), Wade et al., (1984) and Lincoln et al., (1989)

that there is no relationship between the hemisphere involved and the levels of independence as scored on the Rankin scale.

However, when a different variable is introduced such as time (Blanc-Garin, 1994) required to achieve independence, the findings are less clear. Blanc-Garin (1994) not only suggests, that patients with right brain damage (RBD) take longer to acquire independence, but also that they are more difficult to rehabilitate than patients with left brain damage (LBD). In Jongbloed's review of functional prediction after a stroke (1986) he cites, a study by Denes et al., (1982) in which RBD patients apparently showed less improvement with poorer recovery of function than LBD patients, Denes suggesting that this was due, in part, to the presence of unilateral spatial neglect.

10.5.3 Unilateral Spatial Neglect and Site of Lesion

Riddoch (1995) in her recent review of issues in recovery and rehabilitation of stroke patients, suggests that RBD is often associated with other deficits in particular unilateral spatial neglect and cites Denes et al., (1982) view that it is this that hampers recovery. During the present study 69 patients were scored on the National Institute of Health Stroke scale (NIH) (Brott et al., 1989), one item of which measures the patient's level of unilateral spatial neglect. To establish whether, there was an association between the site of the CVA and the Neglect score on the NIH stroke scale data from the 69 subjects in the study was analysed as follows:

i) Observed number of hemispheres involved

Neglect Score on NIH	L	R	Total
0	17	17	34
1	15	14	29
2	1	5	6
Total	33	36	69

ii) The null hypothesis being, that there is no association between the site of the CVA and the level of unilateral spatial neglect as scored on the NIH.

iii) The alternate hypothesis being that there is an association between the site of the CVA and the level of unilateral spatial neglect as scored on the NIH. Calculations included in Appendix 3.9.1.

iv) Calculated $\chi^2 = 2.575$

v) Degrees of freedom = 3

vi) Tabulated $\chi^2 = 5.9$

vii) Since the calculated $\chi^2 <$ tabulated χ^2 the null hypothesis is accepted and the alternate hypothesis rejected

viii) Hence:

No statistical significant association was found between the site of the CVA and the level of unilateral spatial neglect scored on the NIH at the commencement of the episode of care on the stroke unit.

This analysis of 69 patients would suggest that there was no association between the level of unilateral spatial neglect and the hemisphere involved, these findings being in conflict with the findings of Denes et al., (1982).

When the findings of a study do not support the proposed hypothesis this may be related to one of two factors. Firstly, the theory on which the original assumption was based is inappropriate, or secondly the measurement used is not a valid measure of the variable being researched. In this case the variable concerned being unilateral spatial neglect in RBD patients.

Much work has been published in the literature about both the anatomical structures within the CNS and their functions, contra-lateral neglect being due to damage in the nondominant hemisphere (Wilcock, 1986; Kolb and Wishaw, 1980). Two studies have demonstrated that lesions in the parietal lobe result in contra-lateral loss of awareness and body image (Heilman and Watson, 1977; Hecan and Albert, 1978).

One theory about the cause of neglect relates to the role of the parietal lobe in the integration of sensory stimuli in which Denny-Brown and Chambers (1958) suggested that lesions within the parietal lobe may cause spatial information to be misperceived and

therefore ignored. A second theory suggested by Critchley (1953) and supported by Heilman and Watson (1977) relates to damage resulting in a lack of attention to stimuli received.

The evidence might suggest that, knowledge regarding the functions of the parietal lobe and theories regarding dysfunction or deficits resulting from damage to the parietal lobe are sound. Therefore both the validity of the measures used and the rigor of the research implemented require attention.

Denes et al., used a modified version of the Copying Crosses Test (De Renzi and Faglioni, 1967) to assess unilateral spatial neglect, however the sample tested was very small with a total of only 13 patients, 8 RBD patients with neglect and 5 LBD patients. At six months this pattern changed to 7 RBD and 2 LBD, however if correctly analysed using the Chi square test it is difficult to see how this pattern could be significant, particularly the initial data of 8 versus 5 because of the small numbers involved in the analysis.

During the present study 69 patients were assessed at admission, however there was no statistical significance between the NIH Neglect scores and the hemisphere involved. It is interesting to note that 5 RBD patients and 1 LBD patient had a score of 2 denoting the most severe form of neglect, whilst scores of 1 and 0 were evenly distributed between patients. This might suggest that the definitions of 1 and 0 are not valid measures of unilateral neglect or that they are not sensitive enough to record clinically significant differences between the patient groups.

In reviewing the development of the NIH it is apparent that Brott et al., (1989) studied only 10 stroke patients, using a combination of four assessment forms resulting in 15 items each scored without weighting either a 0-3 or a 0-2 ordinal scale. Validation consisted of summing scores from 65 patients and correlating them with CT examination and clinical outcomes at 3 months, scale-lesion $r = 0.68$ and scale-outcome $r = 0.79$, giving a coefficient of explanation of $r^2 = 0.46$ and $r^2 = 0.62$, respectively.

At 46% and 62% this level of agreement is surprisingly low, as were the initial patient numbers used in the developmental process. Similarly, the mathematical analysis of

summing scores from four assessment tools will have resulted in a loss of definition of individual patient's impairment scores, particularly when trying to establish the validity of a new measure that includes unilateral spatial neglect. Therefore, whilst the original paper demonstrates the interrater reliability of the NIH the individual items may not, in fact, measure what they are supposed to measure (Wade, 1992b). Reliability does not ensure validity (Michels, 1983). This question of validity is further highlighted by Goldstein et al., (1989) in assessing the interreliability of the scale, he suggests validation of the measure must occur, for it to be useful as a tool for quantifying the neurological deficits following a stroke.

The clinical presentation of neglect seen in patients with RBD revolves around the patient's inability to orientate themselves around midline, the centre of gravity and the fine of gravity. Patients classically sit asymmetrically being unaware of this or the limbs involved. Motor skills such as, sit to stand and dynamic sitting are asymmetric, and the patient may become distressed when attempts are made to place them in a midline position. The syndrome classically linked to this form of neglect being known as 'pusher syndrome' (Davies, 1985; Gerber, 1995).

Remembering back to the assumptions on which the definitions of these stroke outcome TELER indicators were based, one of these assumptions stated that *'the ability to maintain postural alignment is dependent on the recovery of selective trunk activity and the ability to perceive midline.'* This assumption redefined as a working hypothesis, stated that an association exists between the high scores on the TELER indicators of Maintain Sit and Dynamic Sit and the site of the lesion. The clinical significance of this being that patients with a right sided CVA may have unilateral spatial neglect that will result in an inability to perceive the midline symmetrical alignment. Clinically the TELER Indicators of Maintained Sit and Dynamic Sit in combination being therefore, a more valid measure of neglect .

To establish whether there was an association between the hemisphere involved and the scores on the TELER Indicators of Maintain Sit and Dynamic Sit the data from both indicators for a total of 42 patients, involved in Phases 11, III and IV was analysed as follows:

i) Observed number of hemispheres involved

TELER scores	L	R	Total
0	4	9	13
1	7	4	11
2	10	7	17
3	1	0	1
Total	22	20	42

ii) The null hypothesis being that there is no association between the hemisphere involved and the TELER scores of Maintained Sit and Dynamic Sit.

iii) The alternate hypothesis being that there is an association between the hemisphere involved and the TELER scores of Maintained Sit and Dynamic Sit. Calculations included in Appendix 3.9.1.

iv) Calculated $\chi^2 = 4.004$

v) Degrees of freedom = 3

vi) Tabulated $\chi^2 = 7.815$

vii) Since the Calculated $\chi^2 <$ tabulated χ^2 the null hypothesis is accepted and the alternative hypothesis rejected.

viii) Hence:

No statistically significant association was found between the site of the CVA and score on the TELER Maintain Sit and Dynamic Sit Indicators.

It is difficult to see how Denes et al., (1982) are able to conclude that: '*Unilateral spatial neglect, which is more frequent and severe in the group of left hemiplegics, seems to be crucial in hampering their performance*'. In his sample of 24 RBD patients there were 8 with unilateral spatial neglect, and in his sample of 24 LBD patients 5 had unilateral spatial neglect. Analysing this data using chi-square test as the data from this study was analysed would not provide evidence of a statistically significant difference between the groups of patient. This can be demonstrated as follows:

i) Observed number of hemispheres involved

Copying Crosses Test	L	R	Total
No Unilateral Spatial Neglect	19	16	35
Unilateral Spatial Neglect	5	8	13
Total	24	24	48

ii) The null hypothesis being that there is no association between the hemisphere involved and unilateral spatial neglect as assessed on the Copying Crosses test.

iii) The alternate hypothesis being that there is an association between the hemisphere involved and unilateral spatial neglect as assessed on the Copying Crosses test.

Calculations included in Appendix 3.9.1.

iv) Calculated $\chi^2 = 0.95$

v) Degrees of freedom = 1

vi) Tabulated $\chi^2 = 3.84$

vii) Since the calculated $\chi^2 < \text{tabulated } \chi^2$ the null hypothesis is accepted and the alternate hypothesis is rejected.

viii) Hence:

No statistically significant association was found between the site of the CVA and the assessment of unilateral spatial neglect using the Copying Crosses Test.

Occasionally researchers use the chi-square formula to analyse percentages data as follows:

$$\begin{aligned}
 \text{Calculated } \chi^2 &= \Sigma \frac{\frac{O \times 100 - E \times 100}{T}}{\frac{E \times 100}{T}} \\
 &= \frac{100^2 (O - E)^2}{T} \\
 &= \frac{100}{T} \frac{(O - E)^2}{E}
 \end{aligned}$$

$$= \frac{100}{48} \frac{(0 - E)^2}{E}$$

$$= 2 \frac{(0 - E)^2}{E}$$

T = Total number of patients in study. Substituting the total number of patients involved in the Denes et al., study T = 48 it can be seen that this method of analysis will have the effect of increasing the calculated χ^2 by a factor of 2 thereby producing a type I error with an inappropriate rejection of the null hypothesis.

Analysing the Denes et al., data using a chi-square formula with percentage it can be seen that statistical significance can be achieved as follows:

i) Observed Percentage of hemispheres involved

Copying Crosses Test	L	R	Total
No Unilateral Spatial Neglect	10%	17%	48(100%)
Unilateral Spatial Neglect	40%	33%	48(100%)
Total			100%

ii) The null hypothesis being that there is no association between the hemisphere involved and unilateral spatial neglect as assessed on the Copying Crosses test.

iii) The alternate hypothesis being that there is an association between the hemisphere involved and unilateral spatial neglect as assessed on the Copying Crosses test. Calculations included in Appendix 3.9.1.

iv) Calculated $\chi^2 = 19.125$

v) Degrees of freedom = 1

vi) Tabulated $\chi^2 = 3.84$

vii) Since the calculated $\chi^2 >$ tabulated χ^2 the null hypothesis is rejected and the alternate hypothesis is accepted.

viii) Hence:

Because LBD patients with unilateral neglect contribute 9 (47%) of the χ^2 value of 19.125 a statistically significant association exists between the site of the CVA and the assessment of unilateral spatial neglect.

If this method of analysis was used, it might explain why Denes suggests the significance of his findings. However, this example serves to demonstrate that the association between unilateral spatial neglect and the location of the lesion would have been distorted by this method of analysis to such an extent that statistical significance was erroneously established.

TABLE 18

TELER Maintain Sitting and Dynamic Sitting Scores and Hemisphere Involved as Row Percentages

TELER scores	L	R	Total
0	31%	69%	13(100%)
1	64%	36%	11(100%)
2	58%	42%	17(100%)
3	100%	0%	1(100%)
Total	52%	48%	42(100%)

TABLE 19

TELER Maintain Sitting Scores and Hemisphere Involved as Row Percentages

TELER scores	L	R	Total
0	33%	66%	6(100%)
1	100%	0%	2(100%)
2	66%	33%	6(100%)
Total	57%	43%	14(100%)

When data from the present study is given as a percentage, it can be seen that 69% of the RBD patients had a 0 score on the TELER Indicators and 31% of the LBD patients see table 18. Similarly when the Maintained Sitting Indicator data was analysed without the

Dynamic Sitting Indicator scores the same proportion of patients' scores were recorded, 66% of RBD patients having scores of 0 and 33% of LBD patients see table 19. Interestingly when both sets of data were presented in this way the percentages were higher than those proposed by Denes et al., (1982). However, using chi-square test correctly the association between the NIH scores or the TELER scores and the site of the lesion was not statistically significant.

The numbers involved are far too small to establish whether the two TELER indicators are a more valid measure of unilateral spatial neglect than the NIH. Data analysed was not a true reflection of the patients' admission status as all the TELER scores were recorded as the maximum achieved during the first treatment session, and is therefore not a comparable baseline admission score. These findings would suggest that further research regarding both the validity of the Indicators as measures of neglect and their potential for predicting the outcome of rehabilitation would be valuable and worthwhile.

10.5.4 Patterns of Recovery, Interruption of Motor Relearning

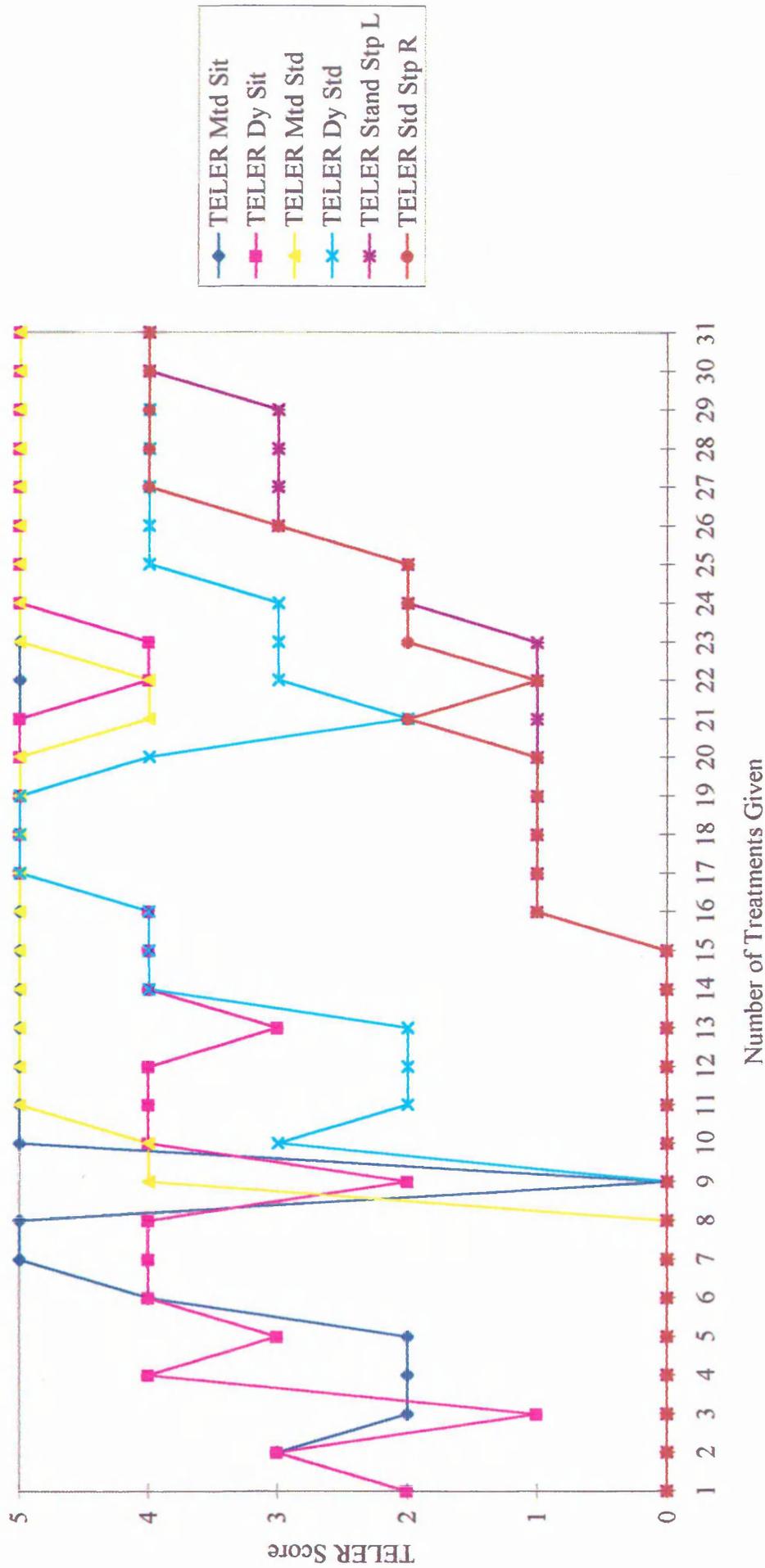
During this phase a total of 160 goals were recorded of which 129, 81 % demonstrated a consolidation acquisition pattern of recovery (see appendix 2.2). This pattern together with the recording of '*fallbacks*' in achievement can be seen in graph 3.

The '*fallback*' in scores noted for the indicators of Maintained Sit and Dynamic Sit and recorded at treatment 9 was following a weekend, when no physiotherapy was given. Similarly the '*fallbacks*' in scores recorded at treatment 21 in the Indicators of Maintained Stand and Dynamic Stand, were following a bank holiday weekend that resulted in no treatment for 11 days. Interestingly achievements lost earlier, were not lost during the bank holiday weekend break, suggesting perhaps a more permanent neurophysiological mechanism.

To establish whether the '*fallbacks*' identified following a break of no treatment lasting longer than 2 days were attributable to a change in the patients' management, or to random occurrences contingency tables were used to analyse whether the pattern of 1, D or NC during rehabilitation was related to treatment periods or no treatment periods.

Graph 3

The Recovery of Motor Function During the Implementation of Physiotherapy Demonstrating Plateaus in Recovery



The hypothesis being that there is an association between a lack of treatment lasting longer than 2 days and a deterioration in the patients' ability to achieve components of certain motor tasks.

10.5.4.1 *Results Obtained from Individual Patients*

To estimate the probability of the pattern traced being attributable to a change in the patient's management data points of 1, NC or D were used as the ordinal categories of a contingency table. Data was tabulated for each Indicator on the assumption that each Indicator was an independent measure of functional recovery, and the Chi square test was used to establish whether patterns traced during both treatment and no treatment periods were non-random or random occurrences.

Independence of data points is an essential requirement when using the Chi Square test on contingency table data. Ottenbacher (1995) in a recent article on the uses of the Chi square test in rehabilitation research, cites Lewis and Burk's (1949) discussion that the most important requirements in the use of this test, is the independence measures used. Ottenbacher continues by suggesting that if all observations and responses recorded are not independent data points, this will result in an increase in the false rejection of the null hypothesis producing a type I error.

The first set of data analysed for Patient A RH2, are the scores obtained during rehabilitation on the following functional goals, the outcome of intervention being scored on the appropriate TELER indicator:

Maintained Sitting
Sit to Stand
Standing to Step Right Leg
Standing to Step Left Leg

Clearly neither indicator was a proxy for the other, each requiring different levels of muscle activity as the base of support changes becoming smaller from one indicator to

another (Charlton, 1994). Any 1, NC or D observed in the clinically significant steps of the TELER Indicator must therefore be assumed to be independent data points.

The pattern recorded during subject A's 24 treatment sessions was the consolidation and acquisition or '*step and plateau*' pattern recorded repeatedly, during this study. The scores documented were the maximum motor achievement during each physiotherapy session. It was noted that '*fallbacks*' or D in the patient's ability to achieve motor skills occurred during the recovery process and these '*fallbacks*' were found subsequently, to be following weekend or breaks in treatment lasting longer than 2 days, (See graph 2). This data was analysed to determine whether the pattern of D following a break in treatment was statistically significant using contingency tables and the Chi square test. Post WE denotes scores observed, following a period of no physiotherapy (weekend) and Post PT denotes scores observed following physiotherapy. Plateaus of NC with no subsequent I or D were recorded for a maximum time period of 5 days.

The pattern of recovery for Subject A (RH2) on all indicators was analysed as follows:

i) Observed number

Scores	I	NC	0	Total
Post WE	4	10	5	19
Post PT	14	49	1	64
Total	18	59	6	83

ii) The null hypothesis being that there is no association between the '*fallbacks*' or deteriorations (D) scores observed in all TELER indicators and weekend periods of no physiotherapy.

iii) The alternate hypothesis being that there is an association between the '*fallbacks*' or deteriorations (D) scores observed in all TELER indicators and weekend periods of no physiotherapy. Calculations included in Appendix 3.9.1.

iv) Calculated $\chi^2 = 13.933$

v) Degrees of freedom = 2

vi) Tabulated $\chi^2 = 5.99$

vii) Since the calculated $\chi^2 >$ tabulated χ^2 the null hypothesis is rejected and the alternate hypothesis is accepted.

viii) Hence:

Because the Post WE D contributed 9.62 (69%) of the calculated χ^2 value of 13.933 the pattern of 'fallbacks' or deterioration D during the rehabilitation of subject A following no physiotherapy treatment was statistically significant and could not have been a random occurrence.

Further analysis of the pattern traced suggest that the '*fallbacks*' were occurring in the more complex motor skills of standing and stepping and during a specific time period, (see graph 2). During the first time period of two weeks following the stroke, there were no '*fallbacks*' although a consolidation and acquisition pattern occurred. After the 2 week period both a consolidation acquisition and '*fallback*' pattern occurred.

As the analysis demonstrated that the patterns of '*fallbacks*' recorded following no physiotherapy, were statistically significant they must be attributable to some process. Observation that two distinct time periods may be involved might suggest that there are two processes occurring during the recovery of motor skills, one process based on the theories of diaschisis (Duncan and Badke, 1989), the other on the theories of motor relearning (Ebbinghaus, 1885; Kandel, 1989; Matthies, 1989). Whilst it might be suggested that during the first time period what is often called '*spontaneous*' recovery may explain the improvements, the deteriorations observed during the second time period, could not be attributable to '*spontaneous*' recovery or diaschisis. These statistically significant '*fallbacks*' must therefore be attributable to a lack of intervention.

To provide further evidence of this association the recovery pattern during 21 treatment sessions of a second patient subject B (HDG2) on all 7 indicators was analysed as follows:

i) Observed numbers

TELER Scores	I	NC	D	Total
Post WE	1	27	5	37
Post PT	14	70	0	84
Total	19	97	5	121

ii) The null hypothesis being that there is no association between the '*fallbacks*' or deteriorations (D) scores observed in all TELER indicators and weekend periods of no physiotherapy for subject B (HDG2).

iii) The alternate hypothesis being that there is an association between the '*fallbacks*' or deteriorations (D) scores observed in all TELER indicators and weekend periods of no physiotherapy for subject B (HDG2). Calculations included in Appendix 3.9.1.

iv) Calculated $\chi^2 = 11.846$

v) Degrees of freedom = 2

vi) Tabulated $\chi^2 = 5.99$

vii) Since the calculated $\chi^2 >$ tabulated χ^2 the null hypothesis is rejected and the alternate hypothesis is accepted.

viii) Hence:

Because Post WE D contributed 7.87 (66%) of the χ^2 value of 11.846 the pattern of '*fallbacks*' or deterioration D during the rehabilitation of subject B following no physiotherapy treatment was statistically significant and could not have been a random occurrence.

The analysis of these two single case studies provided evidence that weekend breaks in physiotherapy were associated with a deterioration in the recovery of certain motor skills. During phase III and IV, a further 10 subjects demonstrated '*fallbacks*' or deteriorations in motor recovery following breaks in physiotherapy lasting longer than two days. (see appendix 3). Only patients who had been scored at least three times a week could be included as those with greater periods of '*no score*' could not be distinguished from true weekend breaks in treatment. The analysis of patient MDG3 included, the last post physiotherapy score followed by the first pre physiotherapy score following a weekend break. For all patients, no data was collated following a period of 4 NC, once the patient had reached a score of 5.

Using a random digit table 5 patients were selected, each set of data being analysed as before using chi-square test with a confidence level of 95% (see appendix 3.9.2). For the 5 patients the results were as follows:

Subject	Number of Indicators	Calculated χ^2
NE1	7	10.75
NE2	5	13.63
RH3	4	14.89
NE3	3	7.269
MDG3	4	41.44

For all five patients with a total of 23 TELER indicators a statistically significant association was found between deteriorations in motor task recovery, and weekend breaks in physiotherapy. Referring back to the original presentation of the TELER method of analysis which explained that it was based on the concept of random change with equal probabilities. It will be seen that with 6 patients demonstrating statistical significance 'fallbacks' or D, the probability of this being a random event is 0.015625 $p < 0.025$. If the 'fallbacks' or D occurred from a code other than 5 only 4, patients are required to achieve a probability level of 0.0123 $p < 0.025$. As all the patients in this study were early stroke patients with a significant level of handicap (a mean Rankin score of 4) they all commenced their TELER scores at 0, 1 or 2, therefore, 4 patients would have been sufficient to provide evidence of effect. As this group of 5 patients was a random sample, these results can be inferred to the total population of 10 independent patients, for whom it can therefore be concluded that weekend breaks in physiotherapy resulted in 'fallbacks'.

10.5.4.2 Results for Groups of Patients on Individual Indicators

Whilst the results from subject A and subject B provide evidence of weekend 'fallbacks' following no physiotherapy not being random occurrences, further evidence might be provided by analysing the patterns of recovery during physiotherapy for groups of patients. The time periods recorded, weekends, for the groups of patients were deemed to be independent time periods and the Chi square tests was used to establish statistical significance.

Four TELER Indicators were chosen as these were the most commonly used measure of recovery during Phase 111. The following table shows the number of patients scored on the four indicators as a percentage of the total number of patients involved in the study.

Table 19a)

Number of Patients using TELER Indicators as a Percentage of Row Total

Indicator Used	Number of patients	Total number of patients
Maintained Sitting	6 = 20.7%	29 = 100%
Dynamic Sitting	8 = 27.6%	29 = 100%
Maintained Standing	6 = 20.7%	29 = 100%
Dynamic Stand	10 = 34.5%	29 = 100%

To establish whether weekend fallbacks occurred in the recovery of Dynamic Standing scored on the TELER Indicator of Dynamic Stand ten subjects were analysed as follows:

i) Observed numbers

TELER Scores	I	NC	D	Total
Post WE	6	35	7	48
Post PT	26	104	3	133
Total	32	139	10	181

ii) The null hypothesis being that there is no association between the '*fallbacks*' or deteriorations (D) scores observed on the TELER indicators of Dynamic Stand and weekend periods of no physiotherapy for 10 subjects.

iii) The alternate hypothesis being that there is an association between the '*fallbacks*' or deteriorations (D) scores observed on the TELER indicators of Dynamic Stand and weekend periods of no physiotherapy for 10 subjects. Calculations included in Appendix 3.9.1.

iv) Calculated $\chi^2 = 10.917$

v) Degrees of freedom = 2

vi) Tabulated $\chi^2 = 5.99$

vii) Since the calculated $\chi^2 >$ tabulated χ^2 the null hypothesis is rejected and the alternate hypothesis is accepted.

viii) Hence:

Because Post We D contributed 7.141 (65%) of the calculated χ^2 value of 10.917, the pattern of 'fallbacks' or deterioration D in the recovery of Dynamic Stand during the rehabilitation of 10 subjects following no physiotherapy treatment was statistically significant and could not have been a random occurrence.

To establish whether weekend fallbacks occurred in the recovery of Dynamic Sit scored on the TELER Indicator of Dynamic Sit, 8 subjects were analysed as follows:

i) Observed numbers

TELER Scores	I	NC	0	Total
Post WE	5	22	7	34
Post PT	23	78	3	104
Total	28	100	10	138

ii) The null hypothesis being that there is no association between the '*fallbacks*' or deteriorations (D) scores observed on the TELER indicators of Dynamic Sit and weekend periods of no physiotherapy for 8 subjects.

iii) The alternative hypothesis being that there is an association between the '*fallbacks*' or deteriorations (D) scores observed on the TELER indicators of Dynamic Sit and weekend periods of no physiotherapy for 8 subjects. Calculation included in Appendix 3.9.1.

iv) Calculated $\chi^2 = 12.143$

v) Degrees of freedom = 2

vi) Tabulated $\chi^2 = 5.99$

vii) Since the calculated $\chi^2 >$ tabulated χ^2 the null hypothesis is rejected and the alternate hypothesis is accepted.

viii) Hence: Because Post We D contributed 8.37 (69%) of the calculated χ^2 value of 12.143, the pattern of '*fallbacks*' or deterioration D in the recovery of Dynamic Sit during the rehabilitation of 8 subjects following no physiotherapy treatment was statistically significant and could not have been a random occurrence.

To establish whether weekend fallbacks occurred in the recovery of Maintained Sit scored on the TELER Indicator of Maintained Sit, 6 subjects were analysed as follows:

i) Observed numbers

TELER Scores	I	NC	0	Total
Post WE	8	21	4	33
Post PT	22	69	3	94
Total	30	90	7	127

ii) The null hypothesis being that there is no association between the '*fallbacks*' or deteriorations (D) scores observed on the TELER indicators of Maintained Sit and weekend periods of no physiotherapy for 6 subjects.

iii) The alternate hypothesis being that there is an association between the '*fallbacks*' or deteriorations (D) scores observed on the TELER indicators of Maintained Sit and weekend periods of no physiotherapy for 6 subjects. Calculations included in Appendix 3.9.1.

iv) Calculated $\chi^2 = 3.903$

v) Degrees of freedom = 2

vi) Tabulated $\chi^2 = 5.99$

vii) Since the calculated $\chi^2 <$ tabulated χ^2 the null hypothesis is accepted and the alternate hypothesis is rejected.

viii) Hence:

The pattern of '*fallbacks*' or deterioration D in the recovery of Maintained Sit, during the rehabilitation of 6 subjects following no physiotherapy treatment was not statistically significant

To establish whether weekend fallbacks occurred in the recovery of Maintained Stand scored on the TELER Indicator of Maintained Stand, 6 subjects were analysed as follows:

i) Observed numbers

TELER Scores	I	NC	0	Total
Post WE	5	15	3	23
Post PT	15	54	2	71
Total	20	69	5	94

ii) The null hypothesis being that there is no association between the '*fallbacks*' or deteriorations (D) scores observed on the TELER indicators of Maintained Stand and weekend periods of no physiotherapy for 6 subjects.

iii) The alternate hypothesis being that there is an association between the '*fallbacks*' or deteriorations (D) scores observed on the TELER indicators of Maintained Stand and weekend periods of no physiotherapy for 6 subjects. Calculations included in Appendix 3.9.1.

iv) Calculated $\chi^2 = 3.636$

v) Degrees of freedom = 2

vi) Tabulated $\chi^2 = 5.99$

vii) Since the calculated $\chi^2 <$ tabulated χ^2 the null hypothesis is accepted and the alternate hypothesis is rejected.

iiiv) Hence:

The pattern of '*fallbacks*' or deterioration D in the recovery of Maintain Stand during the rehabilitation of 6 subjects following no physiotherapy treatment was not statistically significant.

From these results it can be seen that the '*fallbacks*' following a period of no physiotherapy were statistically significant in two of the four Indicators analysed, Dynamic Sit and Dynamic Stand being significant, and Maintained Sit and Maintained Stand not significant. To interpret these findings, both the recovery being measured and the multidisciplinary management on a stroke unit need to be identified.

The indicators of Maintain Sit and Maintain Stand, measure the recovery of postural alignment in relation to two different bases of support. The definitions of the indicator are the clinically significant components of aligned sitting and aligned standing, where alignment is defined as being: '*Alignment of the body refers to the arrangement of body segments to one another, as well as the base of support.*' Shumway-Cook and Woolacott (1995)

In both sitting and standing the vertical line of gravity should fall in the midline between bilateral boney markers, such as the mastoid processes, the upper point of the acromio-

clavicular joint, the inferior angle of scapular, the Posterior Superior Iliac Spine (PSIS) and the lateral malleolus of the ankle joint or inferior angle of the patella anteriorly. The ability to achieve the definitions of this motor skill are observable, and realignment may require verbal cues, supporting surfaces or therapeutic techniques such as normalisation of postural tone within the muscles that produce selective trunk activity.

If, as these results might suggest, the patients involved did not lose the ability to achieve the two motor skills of sitting and standing in correct alignment, as measured by the indicator it might be assumed that this was the result of diaschisis as discussed, or the result of input by the nursing team during the periods of time when physiotherapy or occupational therapy were not available.

A number of authors have described the nursing approach in the management of stroke patients as being based on either, a traditional '*compensatory*' approach in which the patient uses what is left to achieve function or a Bobath Approach where bilateral activities are rehabilitated on the assumption the relearning or recovery can occur following a stroke (Borgman and Passarella, 1991; Borgman, 1989; Calliet, 1980).

Passarella and Lewis (1987), demonstrated that patients cared for by nurses implementing the Bobath principles has a '*significant level*' of functional improvement over patients nursed with a traditional approach. The outcome measurement used was the Modified Barthel Index (Granger et al., 1977), however it is difficult to establish whether the patients involved in the study were receiving physiotherapy as well. However, the results of the present study would support these findings, as the ability to sit and stand are prerequisite achievements for the Barthel items of toileting, transfer and mobility.

From this analysis, it can be seen that the recovery of dynamic sitting and dynamic standing was interrupted by breaks in physiotherapy when patients lost the ability to achieve certain aspects of dynamic sitting and dynamic standing previously achieved following physiotherapy. The recovery of maintained sitting and maintained standing was not interrupted by breaks in physiotherapy input and it might be logically assumed that these achievements were not lost as a result of nursing input in the absence of physiotherapy.

10.5.5 The Recovery of Motor Skills, Prerequisites and Dependent Links

'It should be noted that the regaining of balance control in sitting is not a prerequisite for standing. The alignment of the body segments to each other in sitting and standing is different and the biomechanics (and therefore the muscle activity) are also different.'

Carr and Shepherd (1987a)

This theoretical stand point, one of the fundamental differences between the Motor science approach and the Bobath Approach, was analysed using the recovery patterns of four relevant TELER indicators that measured the achievement of both aligned sitting and standing, and dynamic or balanced sitting and standing.

A working hypothesis previously defined from the assumptions identified during the development of the TELER indicators, stated that *'the ability to achieve Maintained Sit is a prerequisite for dynamic sitting, and that this is a prerequisite for Maintained Stand and Dynamic Stand, therefore, there is a dependence between the definitions of the named indicators.'*

A further working hypothesis relating to the dependence of the indicators stated that *'the ability to recover selective trunk activity on a smaller base of support is dependent on the recovery of selective trunk activity on a larger base of support, therefore an association exists between the different bases of support denoted by the indicators of sitting and standing.'*

To test these working hypothesis, contingency tables were used to establish whether there was a dependence between the achievement of the different items or definitions within certain TELER indicators. As before, the data was analysed using the Chi square test to establish whether the patterns recorded were statistically significant.

To establish whether there was an association between scores achieved on the indicator of Maintained Sit with a large base of support and Maintained Stand with a small base of support the scores were placed in a contingency table and analysed as follows:

i) Observed numbers

Maintained Stand	Maintained Sit						Totals
	0	1	2	3	4	5	
0	4	4	10	4	4	10	36
1	4	2	5	1	0	0	12
2	0	0	2	3	3	2	10
3	0	0	1	8	12	1	22
4	0	0	0	0	2	12	14
5	0	0	0	4	0	111	115
Totals	8	6	18	20	21	136	209

ii) The null hypothesis being that there is no association between the ability to achieve maintained sitting on a large base of support and maintained standing on a small base of support.

iii) The alternate hypothesis being that there is an association between the ability to achieve maintained sitting on a large base of support and maintained standing on a small base of support. Calculations included in Appendix 3.9.1.

iv) Calculated $\chi^2 = 231.48$

v) Degrees of freedom = 25

vi) Tabulated $\chi^2 = 37.652$

vii) Since the calculated $\chi^2 >$ than the tabulated χ^2 the null hypothesis is rejected and the alternate hypothesis is accepted.

viii) Hence:

The pattern observed in the first table clearly demonstrated that higher scores on the indicator of Maintained Sit were associated with lower scores on the indicator of Maintained Stand. As scores improved on Maintained Sit there was an associated improvement on the indicator of Maintained Stand. The association between the two indicators is statistically significant, the achievement of Maintained Sit on a large base of support occurring before Maintained Stand on a small base of support.

It will be noted that this pattern is interrupted by 4 data points demonstrating a score of 5 on Maintained Stand and a lower score on Maintained Sit, a reversal of the pattern

demonstrated. Further investigation of this patient revealed that the patient had an old fracture site involving the hemiplegic ankle that resulted in a fixed deformity. For this reason the patient was unable to score above 3 on Maintained Sit, as this requires normal postural alignment of the feet to the base of support. It will also be noted that there are 111 data points in the 5 score box. This, as with all the contingency tables, occurred because scores of 5 were recorded for a maximum of five continuous scores, denoting that a patient had maintained the recovery of the function, without a deterioration a score of 5 being the ultimate outcome from intervention.

To establish whether an association exists between Dynamic Sit on a large base of support and Dynamic Stand on a small base of support, the scores were analysed as follows:

i) Observed numbers

Dynamic Stand	Dynamic Sit						Totals
	0	1	2	3	4	5	
0	5	4	11	5	7	3	35
1	0	0	9	8	8	0	25
2	0	1	2	5	9	1	18
3	0	0	0	12	25	19	56
4	0	0	0	3	18	41	62
5	0	0	0	0	0	42	42
Totals	15	5	22	33	67	106	238

ii) The null hypothesis being that there is no association between the ability to achieve Dynamic Sit on a large base of support and Dynamic Stand on a small base of support.

iii) The alternate hypothesis being that there is an association between the ability to achieve Dynamic Sit on a large base of support and Dynamic Stand on a small base of support. Calculations included in Appendix 3.9.1.

iv) Calculated $\chi^2 = 215.57$

v) Degrees of freedom = 25

vi) Tabulated $\chi^2 = 37.652$

vii) Since the calculated $\chi^2 >$ than the tabulated χ^2 the null hypothesis is rejected and the alternate hypothesis is accepted.

viii) Hence:

The pattern observed in the first table clearly demonstrated that higher scores on the indicator of Dynamic Sit were associated with lower scores on the indicator of Dynamic Stand. As scores improved on Dynamic Sit there was an associated improvement on the indicator of Dynamic Stand. The association between the two indicators is statistically significant, the achievement of Dynamic Sit on a large base of support occurring before Dynamic Stand on a small base of support.

It will be noted that during this analysis there were less scores of 5 on Dynamic Sit and 5 on Dynamic Stand than the previous contingency table. The reason for this being, that these indicators record the recovery of more advanced movement skills, fewer early stroke patients would be anticipated recovering fully within these areas, therefore fewer patients would have a score of 5 on both indicators.

To establish whether an association existed between the achievement of Maintained Stand and Dynamic Stand both being achieved on the same base of support score on the two indicators, were analysed as follows:

i) Observed numbers

Dynamic Stand	Maintained Stand						Totals
	0	1	2	3	4	5	
0	18	9	9	5	2	0	43
1	0	0	4	12	3	6	24
2	0	0	0	1	6	8	15
3	0	0	0	1	4	36	41
4	0	0	0	7	3	83	93
5	0	0	0	0	0	18	18
Totals	18	9	13	26	18	151	234

ii) The null hypothesis being that there is no association between scores on the indicator of Maintained Stand and those scores on the indicator of Dynamic Stand.

iii) The alternate hypothesis being that there is an association between scores on the indicator of Maintained Stand and the scores on the indicator of Dynamic Stand.

Calculations included in Appendix 3.9.1.

iv) Calculated $\chi^2 = 321$

v) Degrees of freedom = 25

vi) Tabulated $\chi^2 = 37.652$

vii) Since the calculated $\chi^2 >$ than the tabulated χ^2 the null hypothesis is rejected and the alternate hypothesis is accepted.

viii) Hence:

The pattern observed in the first table clearly demonstrated that higher scores on the indicator of Maintained Stand were associated with lower scores on the indicator of Dynamic Stand. As scores improved on Maintained Stand there was an associated improvement on the indicator of Dynamic Stand. The association between the two indicators is statistically significant, the achievement of Maintained Stand, occurring before Dynamic Stand.

To establish whether an association existed between the achievement of Maintained Sit and Dynamic Sit both being achieved on the same base of support and scored on the two indicators were analysed as follows:

i) Observed numbers

Dynamic sit	Maintained Sit						Totals
	0	1	2	3	4	5	
0	1	0	0	0	0	0	1
1	6	2	6	0	0	1	15
2	1	4	7	3	1	3	19
3	1	2	1	6	2	6	18
4	1	1	2	20	8	29	61
5	0	0	3	11	0	60	74
Totals	10	9	19	40	11	99	188

ii) The null hypothesis being that there is no association between scores on the indicator of Maintained Sit and the scores on the indicator of Dynamic Sit.

iii) The alternate hypothesis being that there is an association between scores on the indicator of Maintained Sit and the scores on the indicator of Dynamic Sit. Calculations included in Appendix 3.9.1.

iv) Calculated $\chi^2 = 148.944$

v) Degrees of freedom = 25

vi) Tabulated $\chi^2 = 37.653$

vii) Since the calculated $\chi^2 >$ than the tabulated χ^2 the null hypothesis is rejected and the alternate hypothesis is accepted.

viii) Hence:

The pattern observed in the first table demonstrates that the recovery of the two motor tasks Maintained Sit and Dynamic Sit occurred in parallel with most patients achieving the same scores at the same time in the rehabilitation process. The association between the two indicators is statistically significant, the achievement of Maintained Sit occurring in parallel with Dynamic Sit.

As this pattern was quite different to the others presented previously, and as both patterns are statistically significant and therefore attributable to some process, it might be suggested that this is evidence of two underlying processes resulting in the recovery of motor skills.

The motor skills of Maintained and Dynamic Sit were the first tasks to be relearned during the first weeks of rehabilitation in this study. The different pattern of recovery identified in the analysis may support the argument introduced in the previous analysis, of '*fallbacks*' regarding the theoretical basis of recovery.

During the analysis of the characteristic of motor learning, it was suggested that '*fallbacks*' were occurring in the recovery process, and that these '*fallbacks*' were in more complex motor tasks and did not appear to occur in the first few weeks of rehabilitation. The argument that the parallel pattern of motor achievement is not attributable to physiotherapy alone, but also to the theory of Diaschisis and that the pattern of prerequisite motor learning is attributable to Bobath physiotherapy intervention will be discussed in the final chapter of this thesis.

10.5.6 Summary

- No association was found between the site of the CVA and the level of Handicap scored on the Rankin scale at the commencement of the episode of care on the stroke unit.
- No association was found between the site of the CVA and the level of unilateral spatial neglect scored on the NIH at the commencement of the episode of care on the stroke unit.
- No association was found between the site of the CVA and score on the TELER Maintain Sit and Dynamic Sit Indicators.
- The pattern of '*fallbacks*' or deterioration during the rehabilitation of subject A following no physiotherapy treatment was statistically significant, and could not have been a random occurrence.
- The pattern of '*fallbacks*' or deterioration during the rehabilitation of subject B following no physiotherapy treatment was statistically significant and could not have been a random occurrence.
- The pattern of '*fallbacks*' or deterioration in the recovery of Dynamic Stand during the rehabilitation of 10 subjects following no physiotherapy treatment was statistically significant and could not have been a random occurrence.
- The pattern of '*fallbacks*' or deterioration in the recovery of Dynamic Sit during the rehabilitation of 8 subjects following no physiotherapy treatment was statistically significant, and could not have been a random occurrence.
The pattern of '*fallbacks*' or deterioration D in the recovery of Maintained Sit during the rehabilitation of 6 subjects following no physiotherapy treatment, was not statistically significant.
- The pattern of '*fallbacks*' or deterioration in the recovery of Maintain Stand during the rehabilitation of 6 subjects following no physiotherapy treatment, was not statistically significant.

Evidence provided by this study has demonstrated that the relearning of Dynammic Sit and Dynamic Stand were interrupted by breaks in physiotherapy lasting longer than 2

days and the relearning of the motor task of Maintained sitting and Maintained Stand were not interrupted by breaks in treatment.

- The association between the two indicators is statistically significant, the achievement of Maintained Sit on a large base of support occurring before Maintained Standing on a small base of support.
- The association between the two indicators is statistically significant, the achievement of Dynamic Sit on a large base of support occurring before Dynamic Stand on a small base of support.
- The association between the two indicators is statistically significant, the achievement of Maintained Sit occurring before Dynamic Sit on the same base of support.
- The association between the two indicators is statistically significant, the achievement of Maintained Stand occurring before Dynamic Stand on the same base of support.

Evidence provided by this study has demonstrated that an association exists between the recovery of selective trunk activity on a large base of support, and the recovery of selective trunk activity on a small base of support, the one being a prerequisite for the recovery of the other. This link between the recovery of selective trunk activity on different bases of support is in conflict with the views expressed by the developers of the Motor relearning programme.

Evidence provided by this study has demonstrated that there is an association between the recovery of postural alignment, and the recovery of balanced movement on the same base of support, the alignment being a prerequisite for the recovery of balanced movement.

The recovery of Maintained Sit and Dynamic Sit appeared to occur in a more parallel manner; a different pattern from that observed in the recovery of the other motor tasks. As the recovery of sitting occurs first following a stroke, it was hypothesised that the recovery may be attributed to diaschisis and to therapeutic intervention.

During the analysis of subject A's recovery it was noted that the '*fallbacks*' in the recovery of motor tasks only occurred in more complex skills involving smaller bases of support. It was also noted, that whilst plateaus and improvements occurred during the initial two week time period following a stroke, no '*fallbacks*' occurred.

During this phase of the study 160 goals were scored of which 129,81% demonstrated a consolidation and acquisition pattern of recovery.

10.5.7 Concurrent Validity and Interrater Reliability of the TELER Indicators

Definitions

The face and content validity of the definitions of the TELER Indicators were established during Phase 11 of this study, when clinical or informal knowledge was used to define the codes of the Indicators. This informal knowledge was further validated when research on quantitative movement analysis of movement tasks such as Sit to Stand agreed with the clinical knowledge of practising physiotherapists.

However to further assess the psychometric properties of the developed Indicators they were used in a clinical setting, in conjunction with the Motor Assessment Scale (Carr and Shepherd et al., 1985) to evaluate the concurrent validity of the Motor Task Indicators.

The Motor Assessment Scale was chosen for two reasons. Firstly, it was developed to measure the recovery of every day motor tasks following a stroke, the purpose of this study. Secondly, it is based on the Motor Relearning Programme or emerging Movement Science Approach (Carr and Shepherd, 1994b) predominantly used in Australia. This model of stroke rehabilitation would appear, from the original literature review, to differ from the Bobath Approach in two respects. Firstly, the lack of emphasis on selective trunk activity and secondly, that the approach is based on motor relearning the suggestion being that, the Bobath concept does not integrate principles motor learning into its framework. Lennon (1996). Comparing scores and patterns of change recorded in a clinical situation might highlight whether the assumptions made in the literature are, in fact, a true reflection of current physiotherapy practice.

Whilst the interrater reliability of the MAS has been assessed by both Carr and Shepherd et al., (1985) and Poole and Whitney (1988), the process by which the measure was developed is poorly documented. The scale like the TELER Indicator is based on an ordinal scale, the MAS consisting of a 0 - 6 code the definitions of which include components of given motor tasks in a similar way to the TELER Indicators, however the complexity of the tasks are increased by a reduction in the level of assistance required, an increase in the time a patient is able to do a task, the speed a task can be completed, and the distance a task such as walking can be completed.

The MAS consists of 8 items of motor activities plus 1 item which Carr and Shepherd et al., (1985) suggest, measures the level of hyper or hypo tonicity. This item was not used in the present study as the purpose was to assess the sensitivity and validity of the TELER Indicator definitions as a measure of motor function following a stroke.

10.5.7.1. Analysis of the Difference Between Individual Patients and Individual Indicator Scores Using TELER and MAS

The individual TELER Indicator scores and individual MAS item scores for each of the 29 patients included in Phase III were analysed, using the rank correlation coefficient to establish whether there was agreement between the scores and what the strength of the agreement was. Examples of individual patient score analysis will be given where this serves to identify specific points requiring attention, followed by a presentation of all the rank correlation and grouped correlations for specific indicators and MAS items. Any similarities and difference between the two measures of stroke outcome during physiotherapy will then be presented.

10.5.7.1.1 *Individual Indicators*

Subject HM4 TELER (Edge) Sit to Stand and MAS Sit to Stand					
d	d ²				
0	0				
0	0	r	=	1 -	$\frac{6 \times \Sigma d^2}{n(n^2 - 1)}$
1	1				
1	1				
1	1	=	1 -	$\frac{6 \times 17}{3(13^2 - 1)}$	
1	1				
1	1				
1	1	=	1 -	$\frac{102}{2184}$	
1	1				
2	4				
2	4	=	1 -	0.0467	
1	1				
1	1	r	=	0.9533	
$\Sigma d^2 = 17$	r^2	=		91%	
n = 13					

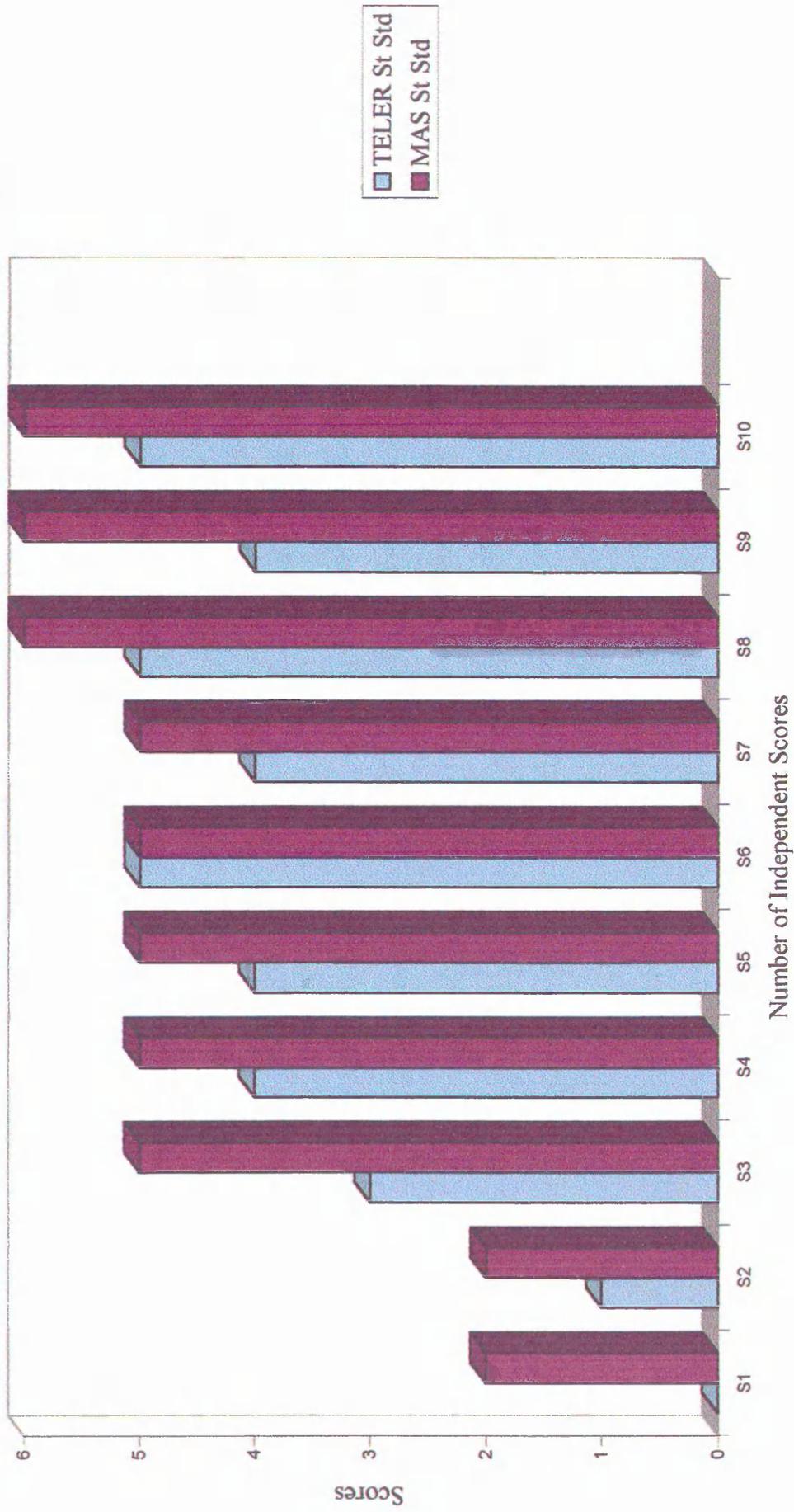
d = difference between TELER score and MAS score

Σd^2 = total of the squares of the differences

During the development of the TELER Indicators in Phase 11 of this study, it became apparent that the Indicator of Sit to Stand required further development, as the clinicians felt patients could achieve the later definitions or clinical steps, but could not achieve the more difficult task of bringing the bottom forward on a chair in preparation for standing. This resulted, as discussed previously, in a change to the published Indicators which became Edge Sit to Stand and the inclusion of a further Indicator of Chair Sit to Edge Sit if required.

Graph 4

TELER and MAS Sit-Stand Scores for Patient RH2 Demonstrating a Lack of Responsiveness in the MAS Definitions



The MAS item of Sit to Stand required the patients to achieve the following clinical steps:

- 0: Unable to achieve task.
- 1: Gets to Standing with help from therapist (any method).
- 2: Gets to Standing with stand-by help (weight unevenly distributed, uses hands for support).
- 3: Gets to standing.
- 4: Gets to standing and stands for 5 seconds with hips and knees extended.
- 5: Sitting to standing to sitting with no stand-by help.
- 6: Sitting to standing to sitting with no stand-by help three times in 10 seconds.

Codes 3 - 6 stipulate that these have to be achieved with symmetrical weight distribution.

As will be seen in the final presentation of all the data for all patients, the correlations for TELER Sit to Stand and MAS Sit to Stand score were high. Occasionally the MAS score and the TELER score did not agree, this may be a reflection of the fact that the MAS item includes four motor tasks; chair sit to edge sit, sit to stand, stand and stand to sit. Graph 4 demonstrates this lack of agreement clearly, the rank correlation for these scores was $r = 0.89$, the strength of the agreement being small with $r^2 = 79\%$.

This inclusion of four motor tasks within one ordinal scale also compromises the requirements of measurement theory. Remembering back to the original presentation of measurement in rehabilitation, there were a number of requirements to be fulfilled, if a measure was to provide useful information about outcomes. One of the requirements, being that the definitions of the scale must have connectivity, transitivity and symmetry. By combining the motor tasks within a definition these requirements cannot be achieved. It might therefore, be suggested that the MAS indicator of Sit to Stand is not based on sound measurement theory.

During the developmental process two TELER Indicators were defined to be a valid measure of functional sitting as discussed earlier, these were Maintained Sit and Dynamic Sit. Within the MAS there is one item measuring sitting and this is called Balanced

Sitting. The TELER Indicators of Sitting were correlated with the MAS Balanced Sitting, both as individual outcomes and as a combined measure of functional sitting. In both cases the correlations were high. Calculations included in Appendix 3.9.3.

When the TELER Indicators were developed two indicators of standing were defined using the same theoretical basis as for sitting. It was argued that a patient required the ability to achieve a midline stance before the patient could move functionally away from and back to midline. This argument will be discussed subsequently, in the light of previous results relating to prerequisite skills. In order to achieve the motor skill of walking the physiotherapists involved in this study agreed that there were a number of significant clinical steps the patient required to achieve before they could achieve independent walking. These clinically significant steps became the indicator of Stand to Step, an indicator which could be used for either or both left and right legs.

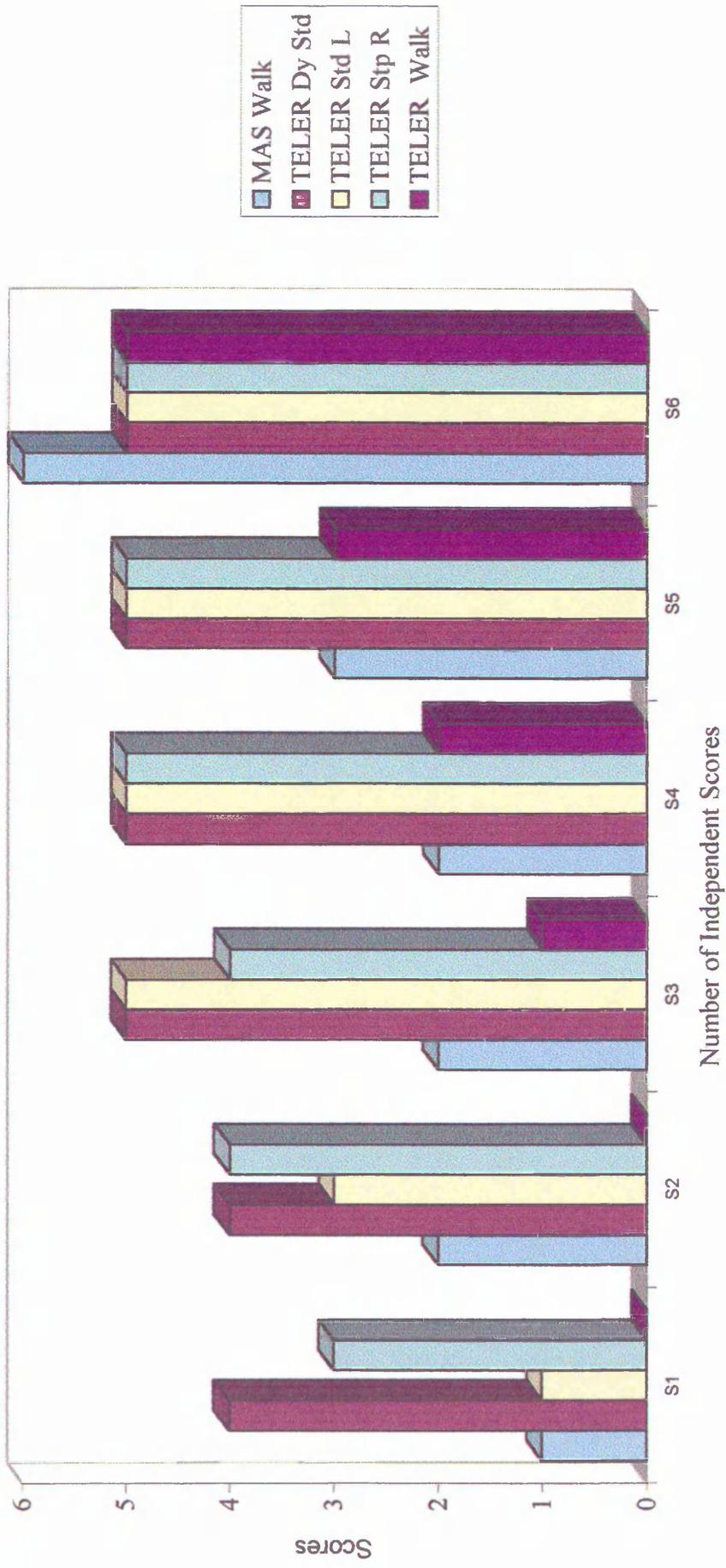
The MAS however, includes only the Sit to Stand item and then a walking item which is included as Code 1:

Able to stand on affected leg and step forward with the other leg (weight bearing hip must be extended. Therapist may give stand-by help) the next code 2 being: Walks with stand-by help from one person.

Because of this lack of clinical responsiveness, and exclusivity within the measurement of aligned and balanced standing, each of the TELER scores were correlated with the MAS walk item individually, and as groups of indicators. Calculations included in Appendix 3.9.3.

In conclusion, it can be seen that the individual items and grouped items available as TELER Indicators of walking rehabilitation, correlate well with the MAS item of Walking. It might be suggested however, that this lack of availability of items within the MAS may result in changes occurring during rehabilitation being missed. This lack of availability of items and resultant lack of responsiveness to change within the MAS can clearly be seen in Graph 5.

TELER and MAS Walking Scores for Patient NE3 Demonstrating a Lack of Availability of Appropriate Items and a Lack of Responsiveness to Clinically Significant Change



During the development of the TELER Indicators for stroke rehabilitation outcomes a number of upper limb Indicators were defined, however consensus on the clinical definitions at the final Delphi round was never reached. These Indicators were included in the validation study and interestingly high levels of correlation were recorded, between these TELER Indicators of Maintained Arm and the MAS item of Upper Arm function.

10.5.7.1.2. Grouping Indicators and Patients to Achieve Overall Correlations

During this final validation of the TELER Indicators 28 patients were scored by an independent therapist, on a total of 78 Indicators with corresponding MAS scores. The rank correlations were high, for both individual Indicators and groups of indicators. See Appendix 3.10 and 3.11.

Of particular interest are the high correlations for the Sitting Indicators, Sit to Stand and Walking. The evidence of correlation between one of the TELER upper limb Indicators and the MAS functional arm item was inconclusive, as the number of scores were low.

To establish the exact distribution of the correlations obtained between TELER and MAS scores the number of times a comparison between scores fell into a given band of correlation was recorded giving a frequency distribution. See Table 20.

When presented in a graphical format it can clearly be seen that the greatest distribution of compared scores fell into the >0.9 grouping. See graph 6.

Whilst the evidence provided by this study, suggests high levels of correlation and agreement between the TELER Motor Task Indicators and certain items on the Motor Assessment Scale there were some clinically significant differences between the measures of stroke outcome.

Graph 6

Frequency Distribution of Rank Correlations Obtained Between TELER and MAS Scores for 28 Patients

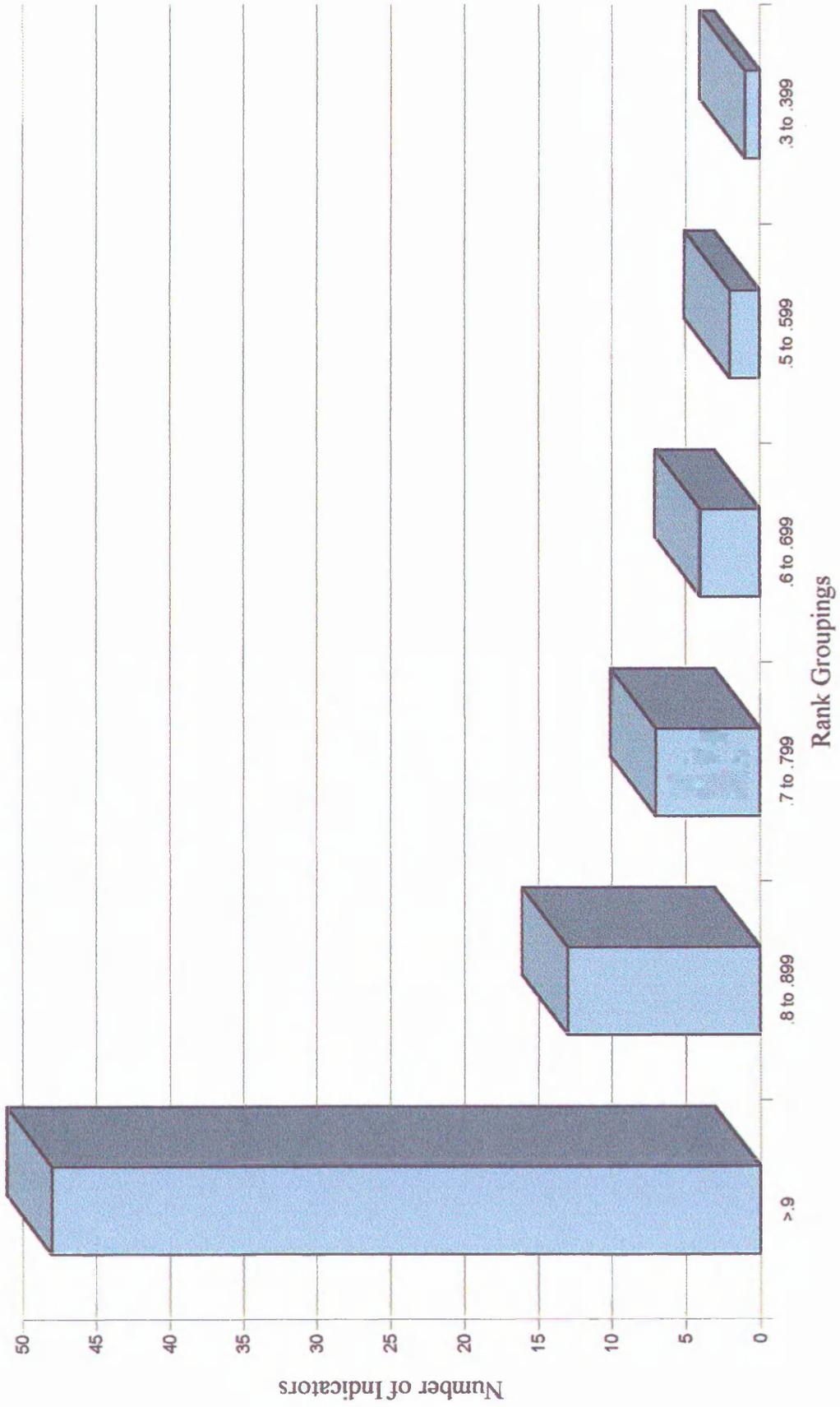


TABLE 20**Frequency Distribution of Rank Correlations Obtained from 76 sets of TELER and MAS Scores n = 28**

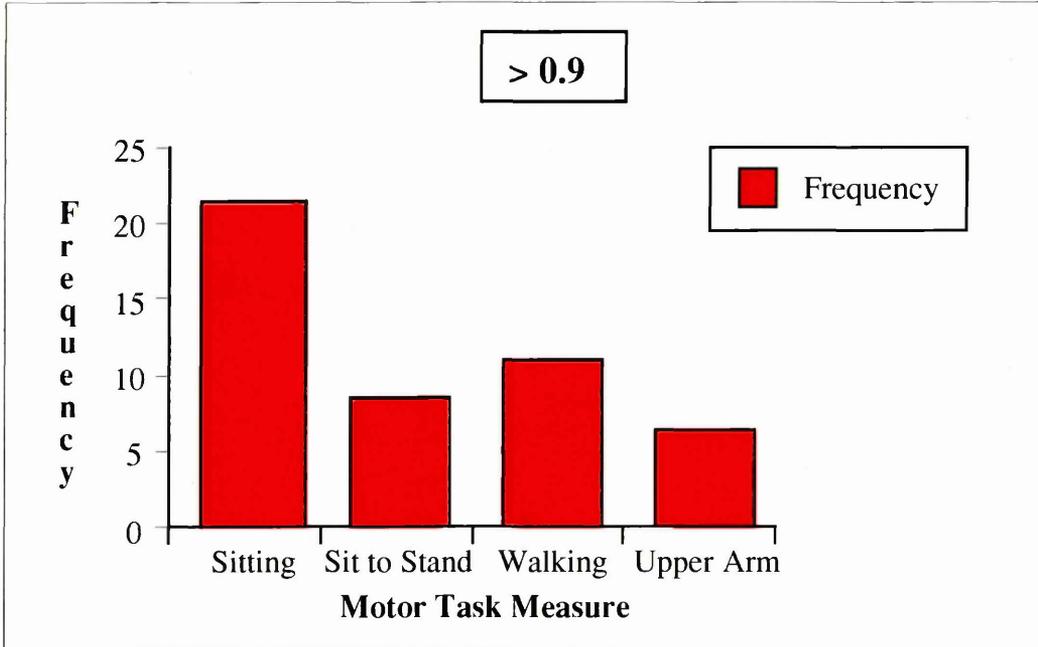
Rank Correlation Group	Number of Indicators	% of Total
> 0.9	49	65%
0.8 to 0.899	13	17%
0.7 to 0.799	7	9%
0.6 to 0.699	4	5%
0.5 to 0.599	2	3%
0.4 to 0.499	0	0%
0.3 to 0.399	1	1%
Total set of scores analyses	76	

The top 4 bands of data were analysed into types of motor task frequency within each Correlation Grouping. Graphs 7a)b)c)d) demonstrate that the measurement of sitting and walking using the TELER indicators and the corresponding items in the MAS resulted in a high level of correlation. As presented earlier (section 10.5.7.1.1) this assumption may be misleading. Looking at the scores obtained on the TELER and the MAS (Graph 4) it can be seen that the TELER Indicator may be more responsive to clinically important change than the MAS item.

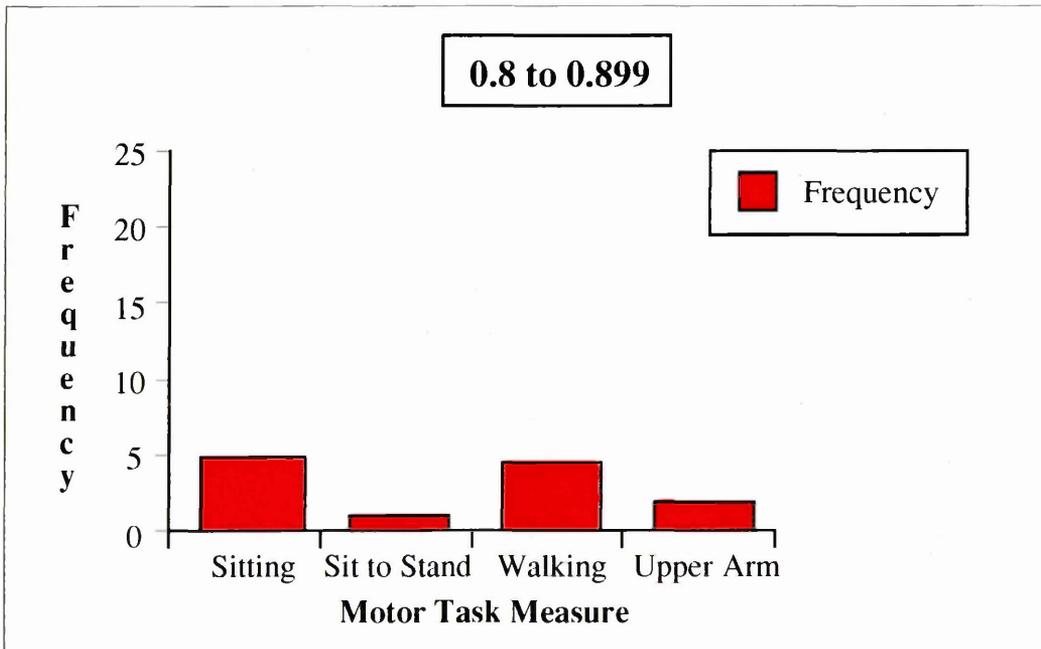
To establish whether the TELER indicator of Sit to Stand was more responsive to change in motor skill ability than the MAS, the scores were analysed for 8 patients using the Chi square test with a confidence level of 95%. The categories identified for analysis were 1, NC and D as a responsive measure should record, both improvements in motor skill and deteriorations in motor skill. Long periods of no change NC, may indicate a lack of responsiveness. It is important to note that these scores were obtained less frequently than might occur in clinical practice, as scores were taken on average three times a week as opposed to daily. When the highest score of 5 on TELER and 6 on MAS was reached with no subsequent D in scores data collection for this analysis ceased, that is no further NC was recorded.

Rank Correlation Frequency of 4 TELER and MAS Outcome Indicators

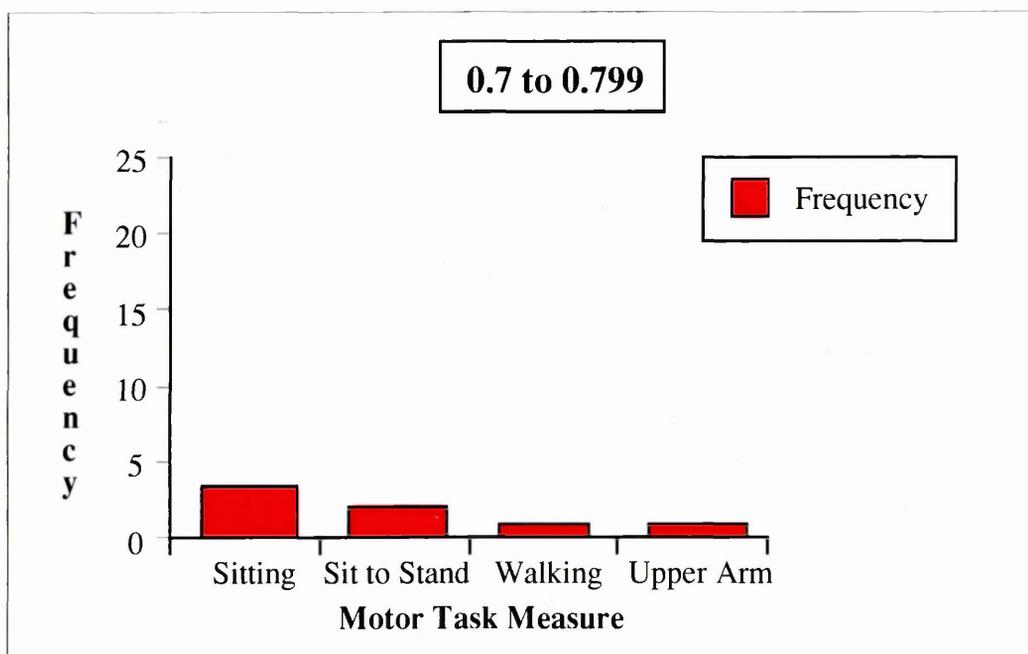
a) Rank Correlations of > 0.9



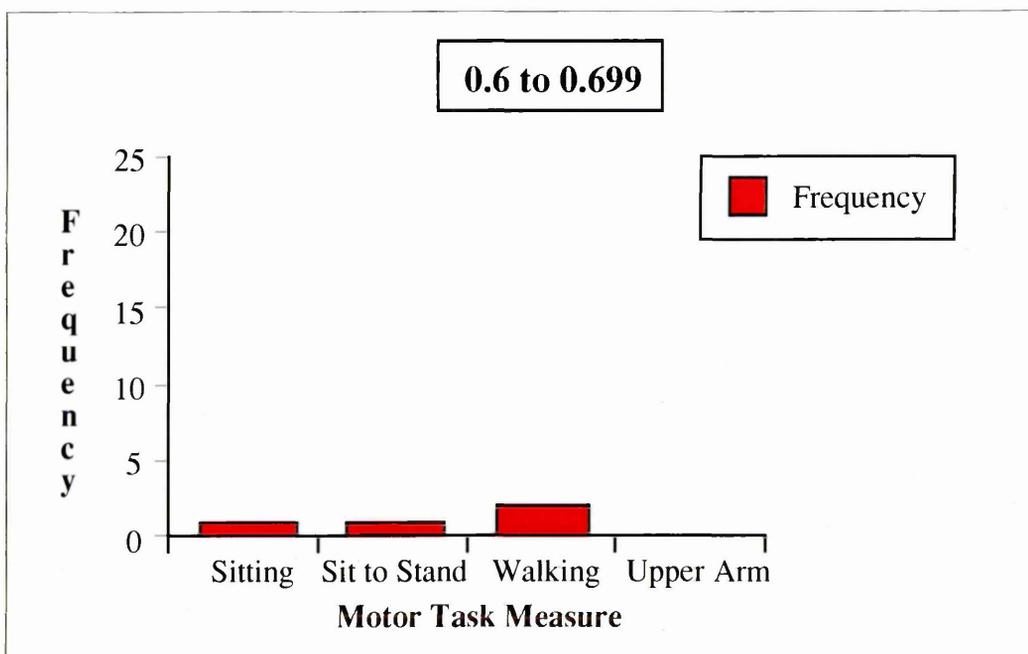
b) Rank Correlations of 0.8 to 0.899



c) Rank Correlations of 0.7 to 0.799



d) Rank Correlations of 0.6 to 0.699



i) Observed numbers

	I	NC	0	Total
TELER	24	26	7	57
MAS	18	44	2	64
Total	42	70	9	121

ii) The null hypothesis being that there is no association between the measure used and the number of changes recorded during the recovery of sit to stand.

iii) The alternate hypothesis being that there is an association between the measure used and the number of changes recorded during the recovery of sit to stand, the TELER indicator recording more I and D than the MAS. Calculations included in Appendix 3.9.3.1.

iv) Calculated $\chi^2 = 7.885$

v) Degrees of freedom = 2

vi) Tabulated $\chi^2 = 5.99$.

vii) Since the Calculated $\chi^2 >$ tabulated χ^2 the null hypothesis is rejected and the alternate hypothesis is accepted.

viii) Hence:

There is a statistically significant difference between the observed and expected distributions of I, NC, and D, for TELER and MAS. The difference occurring because the number of TELER NC, is less than the expected and the number of MAS NC, is more. Therefore TELER has more I and D than MAS and is therefore more responsive to change in both directions.

The purpose of physiotherapy for stroke patients whether it be a Bobath Approach or a Movement Science approach is to induce or prevent changes in both the neurological and musculo skeletal systems of the body. An outcome measure is required to be sufficiently responsive to record or trace the changes that occur during physiotherapy intervention, thereby providing evidence of effect, to be attributed.

The scarcity of standing items and lack of. responsivity of certain MAS items will result in a lack of information provided by MAS. Evidence of attribution will be inconclusive.

In contrast the information provided by the TELER Indicators may be sufficient to demonstrate that the pattern traced is attributable to some process occurring during rehabilitation.

It would appear from this study that whilst both the TELER Motor Task Indicators and certain items in the MAS, both measure the recovery of motor function following a stroke, the MAS does not record important clinical areas of motor recovery and therefore lacks responsiveness to change theoretically induced during physiotherapy. The MAS was developed by Carr and Shepherd et al., (1985) to record an underlying process of motor relearning. The similarity between both the pattern of change recorded and the scores might suggest that, a similar process is occurring during the implementation of the Bobath Approach. This suggestion, which is in conflict with interpretation of the Bobath Approach in the literature, will be discussed in depth in the light of the results of the final phase of this study.

10.5.8 The Reliability of the TELER Indicators

In his book on measurement in neurological rehabilitation reviewed earlier Wade (1992b) suggests that an increase in responsiveness in a measure reduced the overall interrater reliability. The MAS has reported interrater reliability (Carr and Shepherd et al., 1985; Poole and Whitney, 1988) and as it is less responsive than TELER, it might be suggested that TELER is less reliable than MAS. To investigate this possibility the scores obtained by the treating therapist and the independent scorers were examined for 4 of the Indicators used in the validation study, Maintained Sit, Maintained Stand, Dynamic Sit and Dynamic Stand.

The following 4 tables include the scores of both physiotherapists, total agreement would result in all scores failing along a diagonal axis. It can be seen that some scores fall outside this line, however for each indicator only a small percentage of scores lacked agreement.

TABLE 21

Interrater Reliability of the TELER Indicator Dynamic Sit n = 15

		Independent Score						
		0	1	2	3	4	5	
Physiotherapist Score	0	2						
	1		15	2				
	2			41				
	3				23	5		
	4				1	3	33	1
	5						3	25

Total number of scores = 152, 15 (10%) of the scores lacking agreement. Whilst this is a high level of agreement it will be noted that the majority of scores failing out of the diagonal were in the higher score range. These findings were consistent for all 4 indicators analysed.

TABLE 22

Interrater Reliability of the TELER Maintained Sitting Indicator n = 12

		Independent Score						
		0	1	2	3	4	5	
Physiotherapist Score	0	6	1					
	1		8					
	2			18				
	3				4	15		1
	4					2	9	1
	5						4	78

Total number of scores = 147, 13 (9%) of the scores lacking agreement.

TABLE 23**Interrater Reliability of the TELER Maintained Stand Indicator n = 14**

		Independent Score					
		0	1	2	3	4	5
Physiotherapist Score	0	20					
	1		27				
	2			16	3		
	3			2	9	2	
	4		1			14	
	5				1	3	48

Total number of scores = 146, 12 (8%) of the scores lacking agreement.

TABLE 24**Interrater Reliability of the TELER Dynamic Stand Indicator n = 19**

		Independent Score					
		0	1	2	3	4	5
Physiotherapist Score	0	21					
	1		17	2			
	2			15			
	3			1	25	1	
	4				6	35	
	5					1	

Total number of scores 124, 11 (9%) of the scores lacking agreement.

One explanation for the lack of agreement within the higher codes may relate to the definitions themselves. The TELER Indicators developed during this study were to measure the recovery of normal movement.

The last codes of each indicator denoting the most, complex and advanced step required to achieve the named function. This complexity in combination with a requirement for normal recovery will potentially reduce the overall level of reliability between scorers as their observational skills and knowledge base may be variable. The final definition for both Dynamic Sit and Dynamic Stand is theoretically recording the recovery of selective trunk rotation. However, as both Mohr (1990) and Davies (1990) suggest, rotation can be in flexion or extension. This lack of clarity in both TELER indicators may have resulted in the lack of agreement suggesting that the final definitions may require further development.

A review of the TELER forms used revealed, that for one patient the lack of agreement between physiotherapists involved a student physiotherapist. This implies that because the TELER method is based on clinical knowledge, a lack of interrater reliability may result from a lack of knowledge. Monitoring of scores in a peer review situation would not only overcome this problem, but the use of the TELER system would also facilitate the development of both clinical and theoretical knowledge.

Scores were those of the treating physiotherapist and an independent scorer, who theoretically should have been unaware of the score given by the treating therapist. Collusion may have occurred and these results may, in fact, represent agreement between scorers rather than interrater reliability. As the purpose of this phase was to establish the validity of the TELER indicators, this level of agreement is valuable in confirming that the definitions are a valid measure of functional recovery.

It is essential however, to investigate this further in a controlled assessment situation, further research being highly recommended to assess both the inter and interrater reliability of the definitions of the TELER indicators. Of particular interest to the author, would be the relationship between users knowledge base and the ability to accurately score patients on TELER. It should be noted however, that in a clinical setting any fluctuating score should be monitored by a senior physiotherapist, if these fluctuations do not correspond to the patient's anticipated recovery pattern predicted on the basis of informal clinical knowledge.

10.6 Summary

Evidence has been provided by this study that the definitions of the TELER indicators concur with the working hypothesis of the Bobath Approach and the definitions therefore have construct validity.

Correlation between scores recorded on the TELER Indicators and the MAS would indicate that the two measures are measuring the recovery of function following a stroke.

Evidence provided by this study would suggest that the MAS scale is less responsive to change occurring during physiotherapy intervention.

The MAS has less items for the measurement of the recovery of standing and stepping resulting in a further lack of responsiveness to clinically important change within this area.

There is some evidence that, four of the TELER indicators have interrater reliability, however this may be the result of agreement rather than reliability. The assessment of interrater reliability was not in a controlled situation and this therefore requires further research.

PHASE IV MOTOR LEARNING AND RECOVERY OF FUNCTION

11.1 Introduction

'Motor learning is a set of processes associated with practice or experience leading to relatively permanent changes in the capability to respond.'

Schmidt (1988)

In the previous chapter it was established that the TELER normal movement indicators developed by the Bobath physiotherapists during the second phase of this study, measured the same construct as the Motor Assessment Scale developed by Carr and Shepherd that is, the recovery of motor function. Whilst concerns were identified regarding measurement theory and the responsivity of certain items within the MAS, correlations were high between scores on both measures. If the evidence provided is accepted, then it might be suggested that the mechanisms by which this recovery occurs during both the implementation of the Bobath Approach and the Carr and Shepherd Approach is the same, the recovery of motor function being achieved through the relearning of motor tasks.

The concepts and theories of motor learning are of significant importance to the physiotherapist working with stroke patients, however considerable controversy exists regarding the therapeutic models and their modes of practice. Whilst the origins of motor learning theory stemmed from the behavioural sciences (Van Sant, 1991) evidence and application of the concepts have become the domain of the neuroscientists and the neurological therapists.

As reviewed earlier, the literature is lacking in support the changing perspective of certain neurophysiological approaches such as the Bobath Approach (section 4.2.4). The result being, not only a misinterpretation of the present state of the Bobath Approach (4.2.4) but also a lack of proven evidence of the way that the approach is practiced today (section 2.4). Whilst approaches such as Brunnstrom (1970) and Knott and Voss (1968) may still be based on the repetitive evoking of reflexes *'to facilitate postures and*

movement' (Van Sant, 1991), evidence has been provided by this study, that this is not the model of practice used by Bobath trained physiotherapists. The Bobath Tutors and senior physiotherapists involved in the study developed indicators of outcome that were based on the rehabilitation of selective trunk activities, midline orientation and biomechanical realignment as a basis for functional task. Whether the underlying process involved motor relearning was less clear, as much of the initial work prior to volitional activity was facilitated as an automatic movement.

A further example of the apparent misunderstanding of the Bobath Approach can be seen in a paper on motor behaviour research by Mathiowetz and Haugen (1994). The authors like Van Sant, place the Bobath Approach or neurodevelopmental approach in the same theoretical category as Brunnstrom, Knott and Voss and Rood (1954) suggesting that they continue to be based on a *'reflex and hierarchical model of motor control'*.

Mathiowetz and Haugen suggest that the Motor Learning Programme approach developed by Carr and Shepherd (1987 a,b) reviewed earlier (section 5.2.,10.1), was developed to *'address the limitations of the neurodevelopmental approaches and in response to new ideas in the motor behavioural literature.'* Whether it is an accurate statement or not they do continue by correctly suggesting, that the heavy reliance on cognition precludes patients with either cognitive or perceptual deficits. By directly addressing therapeutic processes to the higher cortical centres the Motor Learning Programme is potentially very limited in its uses with stroke patients, a significant number of whom have resultant perceptual impairments (Riddoch, 1995).

In his definition of motor learning, Schmidt (1988) suggests that each process involved is itself a set of events or occurrences that lead to some *'product or change.'* He continues by stating, that these occurrences are associated with practice or experiences and that the change occurring is in the ability to respond.

The Bobath Approach documented during this study draws on this theory of motor learning. The *'events or occurrences'* being selective trunk activities, the *'experience'* being *'normal movement'* and the *'ability to respond'* being the sequencing of the individual items in a motor plan the outcome of which is a functional task. This ensures that the implementation of therapy to enable the relearning of motor control uses

automatic selectivity of trunk activity as a foundation for all functional tasks, irrespective of the patients initial level of cognition or perceptual deficit.

In contrast the Motor Relearning Approach relies on cognition using manual guidance, repetition, and biofeedback. Lennon (1996) in her review of motor relearning suggests that movements must be '*self initiated*' and that '*attempts at skills do not need to be perfect as errors in performance can assist skill acquisition.*' Both assumptions are in conflict with the findings of this study, and the evidence in the literature of neural mechanisms (section 2.4). Self-initiation, when a patient has perceptual deficits, and the practicing of '*imperfect movements*' will lead to compensatory strategies, not recovery. Evidence in the literature (section 2.2., 2.4) would suggest that compensatory movements may limit the potential for the recovery of function (Le Vere, 1980; Held, 1993).

Motor learning and skill acquisition take place throughout life (Van Sant, 1990; Woollacott and Shumway-Cook, 1989) with the establishment of motor Schema (Schmidt, 1975) that can be transferred to a variety of environmental situations. The link between motor learning and the recovery of motor skills following injury is fundamentally important to physiotherapists working with stroke patients. Shumway-Cook and Woollacott (1995) suggest that motor learning and the reacquisition of movement skills are the same process using the terms interchangeably.

Whilst the underlying neurophysiological process are likely to be the same, there are important differences that direct therapeutic intervention. Following injury to the CNS patients may compensate for lacking selectivity of movement (Lynch and Grisogono, 1991) developing abnormal functional characteristics such as asymmetry of weight bearing (Davies, 1990), reduction in stance phase and swing through, (Shumway-Cook and Woollacott, 1995). The starting point is therefore different, the environment of learning is abnormal, sensory information the key to learning (Schmidt, 1988; Adams, 1971; Newell and Rosenbloom, 1981) may be distorted, absent or inappropriate.

This must be addressed as part of the remedial process and it is this that has been the fundamental concept of the Bobath Approach, abnormal sensory input must be inhibited

to enable the facilitation of normal sensory information and motor output. In relation to motor learning, behaviours may need to be unlearned before they can be relearned.

This concept of unlearning prior to relearning has been presented by Kandel (1989) in the area of psychotic illness where abnormal behaviours must be addressed by psychotherapeutic intervention. As reviewed earlier, research conducted by Kandel and others using the *Aplysia* (Kandel, 1976, 1982; Hawkins, 1983) has provided evidence of structural changes in the CNS that result from alteration in gene expression. Kandel goes further suggesting that:

'normal learning, the learning of neurotic behavioural patterns, and the unlearning of such detrimental behaviours through psychotherapeutic intervention might involve long term functional and structural changes in the brain that result from alterations in gene expression.'

Kandel (1989)

This proposed model of learning and unlearning could similarly be the basis of the Bobath therapeutic process, the recovery of function being the human behaviour to be measured (Robertson and Lee, 1994). The problem for researchers in this area of learning lies in the fact that learning itself cannot be directly measured (Schmidt, 1988). The complex neurophysiological process might have been demonstrated in experimental studies (Kandel, 1982; Matthies, 1989) however, the recorded changes in behaviour must *'allow the logical conclusion that there were associated changes in some internal state'* (Schmidt, 1989).

During this study it has been established that the recovery of function during the implementation of the Bobath Approach occurs in a *'step and plateau'* pattern. As discussed earlier, these findings are in conflict with those of Partridge et al., (1987) who suggested that a linear pattern occurs. The limitations of this research have already been discussed and the evidence provided by this study is considerable. In phases I and III a total of 70 patients were scored on a total of 352 functional indicators or goals. Of these 322 goals, 247 (77%) demonstrated a *'step and plateau'* pattern of functional recovery.

As reviewed earlier, this idea of plateau's or consolidation prior to the acquisition of a skill is not a new concept. Dombovy and Bach-y-Rita (1988) cite Bach-y-Rita and Balliet's (1981a) discussion of this concept. However, as both Dombovy and Bach-y-Rita (1988) and Acheson-Cooper and Saarinen-Rahikka (1991) suggest little information about the nature of the plateau is available.

Using Schmidt's (1988) analogy it might be suggested that the clinically significant steps of the Physical Function TELER Indicator are the observable characteristics of the learning process, any patterns of change traced, may provide evidence of the neurophysiological processes identified by Kandel (1989) and Matthies (1989).

The purpose of this final phase was to investigate the characteristics of the consolidation and acquisition phases occurring in the recovery of functional tasks to establish, whether there was any evidence that motor relearning was occurring during the implementation of the Bobath Approach.

In order to establish whether the consolidation phase or '*no change*' in score was a true phenomena or a reflection of the time of measurement, the achievement of clinically significant definitions would be recorded pre treatment and the maximum attainable score during treatment. In this way information could be obtained regarding the carry over or transfer of skills over time, a prerequisite of learning establishing, whether the Bobath Approach uses a model of motor relearning to achieve functional recovery following a stroke.

11.2 The Approach

As reviewed, Schmidt (1988) suggests that changes in behaviour might logically be a reflection of learning. Robertson and Lee (1994) identified the importance of a single case study design, enabling the definition of '*items of interest*' in human behaviour and the tracing of change in these items over time. The earlier stages of this study, resulted in the development and validation of clinically significant definitions of motor tasks that could then be used as a tool, for the measurement of change in a single case study design. Therefore, a single case study was undertaken using the TELER method of note

making, recording both treatment input and treatment outcomes using the TELER indicators developed and validated in the previous phases of the study.

11.3 Method

During this final stage an acute stroke patient who fulfilled the inclusion criteria identified previously, was assessed and treated by a Bobath trained physiotherapist on the Stroke Unit at the Hallamshire Hospital Sheffield. During this routine clinical episode TELER Indicators were used to trace the change or lack of change occurring during the episode of care. The patient was scored independently by the author pre treatment and during treatment to obtain the maximum score achievable and the score prior to treatment.

11.4 Patient Information Subject A NE5

11.4.1 Previous Medial History

A 76 year old lady with a history of a right CVA resulting in a left hemiplegia two years prior to admission. Further extension of original right CVA two weeks previously. No CTS to confirm site of lesion. Known insulin dependent diabetic. Prior to second CVA walking with a stick, independent around the house although unsure in crowded environments, able to bake, wash and manage stairs.

11.4.2 Drug History

Table 25 Patients Drug History

Drug	Dose
Carbomazepin	200mg tsd
Tismopril	20 mg od
Humulin 1	
Aspirin	75 mg od
BF 2 Singod	
Oxybutinin	5 mg bd
Cocodanol	
Co danthrazate	
Trimethropine	

11.4.3 Social History

Subject A NE5 had smoked previously, and was living at home with her husband who was fit and well. There were stairs in the house with the toilet and bathroom downstairs. Access to the house was by seven steps which led to the front door.

11.4.4 Physical Assessment

Rankin score 4.

Table 26 National Institute of Stroke Health Scale Score

Item	Score	Item	Score
Motor Arm Left	1	Language	0
Motor Leg Left	1	Sensory	0
Dysarthria	0	Neglect	0

11.4.5 Problem List

- Reduced tone in lumbar extensors and left trunk side flexors.
- Reduced tone left hip extensors, left knee extensors and dorsiflexors on the left.
- Positive support reflex active on the left.
- Increased tone in left Pectoral muscles, Latissimis Dorsi and Biceps which increases with effort.
- Reduced tone in upper limb distally.

COMPENSATIONS

- Over activity of right neck Trapezius and right lumbar extensors and side flexors.
- Slight over activity of right upper limb and lower limb.

11.4.6 Functional Consequences

Reduced ability to roll in bed (change base of support).

Unable to transfer from lying to sitting (change base of support).

Unable to sit independently (accept base of support) for dressing, feeding and toileting.

Unable to transfer from sit to stand (change base of support) requiring moderate assistance of two people.

Unable to stand independently or walk independently (accept base of support and change base of support).

11.4.7 TELER Physical Function Indicators

The following indicators were chosen to fulfil the patient's needs and the need identified in the objective assessment. They were used to trace the change or lack of change in the achievement of motor tasks. (See Table 27)

TABLE 27 TELER indicators used in Single Case Study.

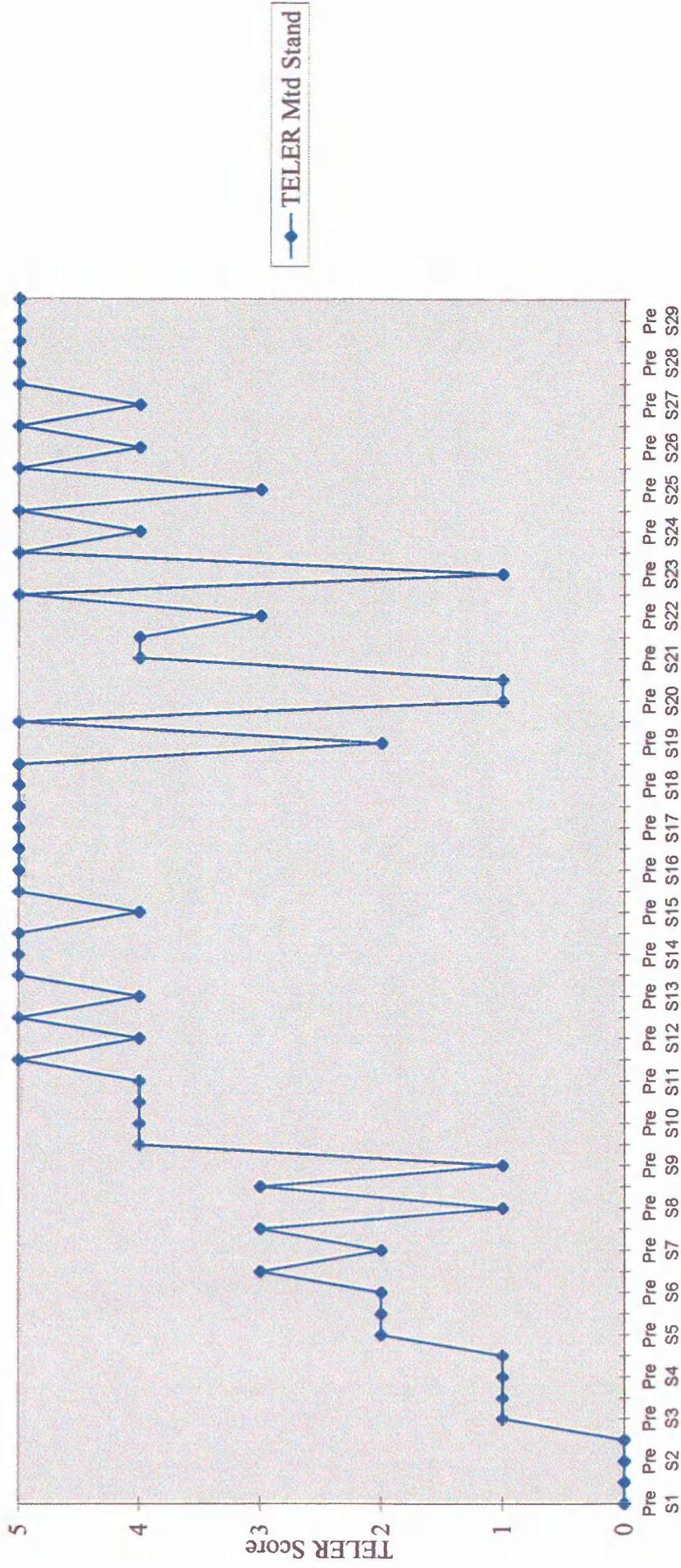
Indicator Name	Commenced Scoring
Maintained Sit	Treatment 1
Dynamic Sit	Treatment 1
Edge Sit to Stand	Treatment 1
Maintained Stand	Treatment 1
Dynamic Stand	Treatment 1
Transfer	Treatment 10
Standing to Stepping Left Leg	Treatment 18
Standing to Stepping Right Leg	Treatment 21
Walking Assistance 1	Treatment 28
Manipulating Arm Left	Treatment 31
Walking with Stick	Treatment 48

11.4.8 Treatment Principles

Initially treatment was directed at regaining trunk stability, with symmetry over the base of support (Davies, 1990; Charlton, 1994) enabling the formation of a stable base from which limb movements could be facilitated. Selectivity of trunk movements were re-educated inhibiting the over activity of compensatory mechanisms. The releasing of both

Graph 8

Recovery Pattern Observed for Patient NE5 Demonstrating Plateaus, Post Weekend 'Fallbacks' and Between treatment 'Fallbacks'.



postural alignment and trunk selectivity would inhibit abnormal tone and provide a normalisation of sensory information received by the CNS (Bach-y-Rita and Balliet, 1987). Rehabilitation of alignment, weight bearing and selectivity of movements would take place in a number of environments, for example lying, sitting and standing enabling the transfer of skills from one to another (Schmidt, 1988; Lee et al., 1991).

Throughout the treatment process the patient would be given feedback (Lynch and Grisogono, 1991) this would be both intrinsic and extrinsic (Shumway-Cook and Woollacott, 1995; Winstein, 1991) ensuring the learning or acquisition of functional tasks. Whilst relearning of individual components of the motor task would be encouraged, the task itself would be practised in a functional setting (Lee et al., 1991).

11.5 Findings

All of the TELER Indicators used, see Table 27, demonstrated that the relearning of motor tasks occurred in a consolidation and acquisition of '*step and plateau*' pattern of recovery and that weekends appeared to result in a loss of motor skill. The pre-treatment and during treatment scores also demonstrated that during certain clinical time periods, repeated fallbacks were occurring within the previously recorded consolidation phase of motor relearning. Graph 8 demonstrates quite clearly all three observations during the recovery of Maintained Standing:

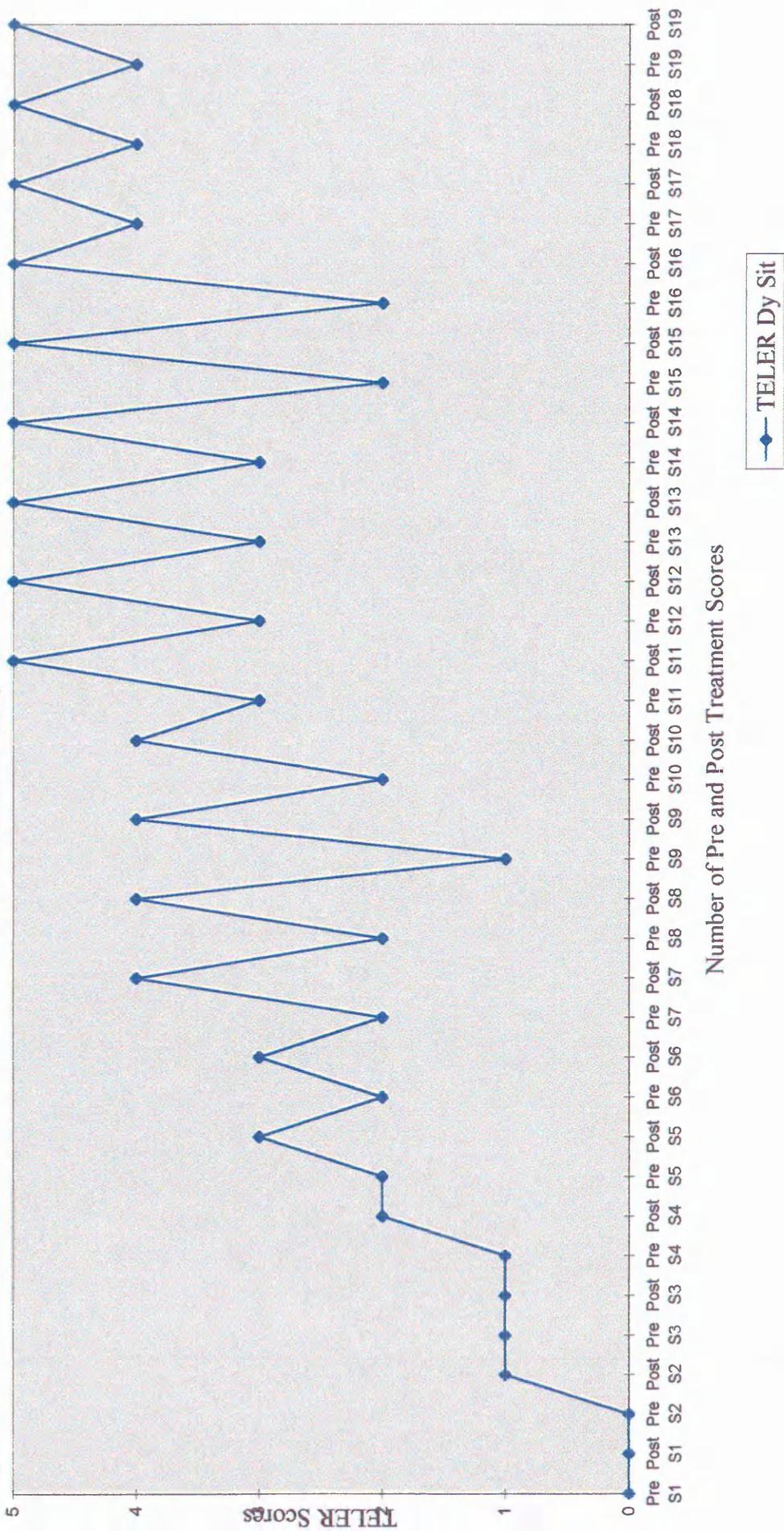
- Consolidation acquisition pattern
- '*Fallback*' in motor skills following weekend breaks in physiotherapy
- Between treatment '*fallbacks*' in previously acquired motor skills

This evidence further supports the findings of Phase 111, suggesting the recovery of function following a stroke, is characterised by the consolidation and acquisition of skills and the interruption of learning resulting in a loss of skill organisation.

Evidence of loss of skill acquisition between treatment sessions, obviously requires further support and to establish the strength of the findings observed during the rehabilitation of Subject A NE5, 3 further patients scored pre-treatment and during

Graph 9

Recovery Pattern Observed for Patient MDG3 Demonstrating Two Different Patterns of Recovery : Diaschisis and Motor Relearning



treatment during phase III were included in the analysis. The demographics data of these patients is summarised in table 28.

TABLE 28

Demographic Data for 3 Subjects Included in Phase IV Analysis of Between Treatment 'Fallbacks'

Subject	Age	Location of Stroke	Rankin Score
B (ML2)	NA	Left	4
C(MDG2)	55	Left	5
D(MDG3)	64	Left	4

Like subject ANE5 all 3 patients demonstrated '*fallbacks*' in motor skill acquisition between treatment sessions. This can be seen in Graph 9 demonstrating the observed recovery of sitting scored on the TELER Indicator of Dynamic Sit. Therefore a working hypothesis was identified as follows:

- * an association exists between the '*fallbacks*' observed during the recovery of motor function and periods of no treatment that occur between treatment sessions.

The patterns of change traced were analysed for subject ANE5 using indicators of Sit and Stand and for all the patients scored in this way for the indicator of Dynamic Sit. Contingency tables were used with improvement (I), no change (NC) or deterioration (D) being the ordinal categories. The Chi square test of goodness of fit was used to determine whether the pattern recorded was statistically significant, and therefore attributable, or a random occurrence. When using the Chi-square test a confidence level of 95% was used, that is if $p < 0.05$ the null hypothesis is rejected and the alternate hypothesis that the observed association or dependence between variables exists, is accepted.

To establish whether between treatment '*fallbacks*' occurred in the recovery of Maintained Sit during 11 treatment sessions for subject A NE5 the scores on the TELER indicator of Maintained Sit were analysed as follows:

i) Observed numbers

	I	NC	D	Total
Pre-treatment → Treatment	9	3	0	12
Treatment → Pre-treatment	0	5	6	11
Total	9	8	6	23

ii) The null hypothesis being that there is no association between the '*fallbacks*' or deterioration (D) scores observed on the TELER of Maintained Sit and between treatment periods of no treatment for subject A NE5.

iii) The alternative hypothesis being that there is an association between the '*fallbacks*' or deterioration (D) scores observed on the TELER of Maintained Sit and between treatment periods of no treatment for subject A N E5. Calculations included in Appendix 3.9.4

iv) Calculated $\chi^2 = 15.5$

v) Degrees of freedom = 2

vi) Tabulated $\chi^2 = 5.99$

vii) Since the calculated $\chi^2 >$ tabulated χ^2 the null hypothesis is rejected and the alternate hypothesis is accepted.

viii) Hence, there is a statistically significant difference between the observed and expected distributions of I, NC, and D for Pre-treatment I Treatment scores versus Treatment I Pre-treatment scores. The difference occurring because the number of Treatment I Pre-treatment deteriorations D, are more than the number of Pre-treatment/Treatments deteriorations D. Therefore, the deteriorations recorded in Maintained Sit, between treatment sessions for subject A NE5 could not have been a random occurrence.

To establish whether between treatment '*fallbacks*' occurred in the recovery of Dynamic Sit during 27 treatment sessions for subject A NE5 the scores on the TELER indicator of Dynamic Sit were analysed as follows:

i) Observed numbers

	I	NC	D	Total
Pre-treatment → Treatment	15	11	1	27
Treatment → Pre-treatment	2	12	13	27
Total	17	23	14	54

ii) The null hypothesis being that there is no association between the '*fallbacks*' or deterioration (D) scores observed on the TELER of Dynamic Sit and between treatment periods of no treatment for subject A NE5.

iii) The alternative hypothesis being that there is an association between the '*fallbacks*' or deterioration (D) scores observed on the TELER of Dynamic Sit and between treatment periods of no treatment for subject A NE5. Calculations included in Appendix 3.9.4.

iv) Calculated $\chi^2 = 20.26$

v) Degrees of freedom = 2

vi) Tabulated $\chi^2 = 5.99$

vii) Since the calculated $\chi^2 >$ tabulated χ^2 the null hypothesis is rejected and the alternate hypothesis is accepted.

viii) Hence, there is a statistically significant difference between the observed and expected distributions of I, NC, and D for Pre-treatment I Treatment scores versus Treatment I Pre-treatment scores. The difference occurring because the number of Treatment I Pre-treatment deteriorations D, are more than the number of Pre-treatment/Treatments deteriorations D. Therefore, the deteriorations recorded in Dynamic Sit, between treatment sessions for subject A NE5 could not have been a random occurrence.

To establish whether between treatment '*fallbacks*' occurred in the recovery of Maintained Stand during 29 treatment sessions for subject ANE5 the scores on the TELER indicator of Maintained Stand were analysed as follows:

i) Observed numbers

	I	NC	D	Total
Pre-treatment → Treatment	18	10	1	29
Treatment → Pre- treatment	0	15	15	30
Total	18	25	16	59

ii) The null hypothesis being that there is no association between the '*fallbacks*' or deterioration (D) scores observed on the TELER of Maintained Stand and between treatment periods of no treatment for subject A NES.

iii) The alternative hypothesis being that there is an association between the '*fallbacks*' or deterioration (D) scores observed on the TELER of Maintained Stand and between treatment periods of no treatment for subject A NE5. Calculations included in Appendix 3.9.4.

iv) Calculated $\chi^2 = 31.07$

v) Degrees of freedom = 2

vi) Tabulated $\chi^2 = 5.99$

vii) Since the calculated $\chi^2 >$ tabulated χ^2 the null hypothesis is rejected and the alternate hypothesis is accepted.

viii) Hence, there is a statistically significant difference between the observed and expected distributions of I, NC, and D for Pre-treatment I Treatment scores versus Treatment I Pre-treatment scores. The difference occurring because the number of Treatment I Pre-treatment deteriorations D, are more than the number of Pre-treatment /Treatments deteriorations D. Therefore, the deteriorations recorded in Maintained Stand, between treatment sessions for subject A NE5 could not have been a random occurrence.

To establish whether between treatment '*fallbacks*' occurred in the recovery of Dynamic Standing during 32 treatment sessions for subject ANE5 the scores on the TELER indicator of Dynamic Stand were analysed as follows:

i) Observed numbers

	I	NC	D	Total
Pre-treatment → Treatment	15	11	0	26
Treatment → pre- treatment	1	11	13	25
Total	16	22	13	51

ii) The null hypothesis being that there is no association between the '*fallbacks*' or deterioration (D) scores observed on the TELER of Dynamic Stand and between treatment periods of no treatment for subject ANE5.

iii) The alternative hypothesis being that there is an association between the '*fallbacks*' or deterioration (D) scores observed on the TELER of Dynamic Stand and between treatment periods of no treatment for subject ANE5. Calculations included in Appendix 3.9.4.

iv) Calculated $\chi^2 = 24.95$

v) Degrees of freedom = 2

vi) Tabulated $\chi^2 = 5.99$

vii) Since the calculated $\chi^2 >$ tabulated χ^2 the null hypothesis is rejected and the alternate hypothesis is accepted.

viii) Hence, there is a statistically significant difference between the observed and expected distributions of I, NC, and D for Pre-treatment I Treatment scores versus Treatment I Pre-treatment scores. The difference occurring because the number of Treatment I Pre-treatment deteriorations D, are more than the number of Pre-treatment /Treatments deteriorations D. Therefore, the deteriorations recorded in Dynamic Stand, between treatment sessions for subject A NE5 could not have been a random occurrence.

To establish whether between treatment '*fallbacks*' occurred in the recovery of Dynamic Sit for 4 subjects including ANE5 the scores on the TELER indicator of Dynamic Sit were analysed as follows:

i) Observed numbers

	I	NC	D	Total
Pre-treatment → Treatment	47	15	1	63
Treatment → pre- treatment	2	16	41	59
Total	49	31	42	122

ii) The null hypothesis being that there is no association between the '*fallbacks*' or deterioration (D) scores observed on the TELER of Dynamic Sit and between treatment periods of no treatment for 4 subjects.

iii) The alternative hypothesis being that there is an association between the '*fallbacks*' or deterioration (D) scores observed on the TELER of Dynamic Sit and between treatment periods of no treatment for 4 subjects. Calculations included in Appendix 3.9.64.

iv) Calculated $\chi^2 = 79.38$

v) Degrees of freedom = 2

vi) Tabulated $\chi^2 = 5.99$

vii) Since the calculated $\chi^2 >$ tabulated χ^2 the null hypothesis is rejected and the alternate hypothesis is accepted.

viii) Hence, there is a statistically significant difference between the observed and expected distributions of I, NC, and D for Pre-treatment I Treatment scores versus Treatment I Pre-treatment scores. The difference occurring because the number of Treatment I Pre-treatment deteriorations D, are more than the number of Pre-treatment /Treatments deteriorations D. Therefore, the deteriorations recorded in Dynamic Sit, between treatment sessions for subject A NE5 could not - have been a random occurrence.

As previously discussed, when using the χ^2 test to establish the statistical significance of observed patterns, it is essential that the measurements compared are independent. It might be argued that there is a lack of independence between pre-treatment and treatment scores, and treatment and pre-treatment scores. Theoretically, the effects of

treatment whether that be at synaptic levels or cellular level within the CNS or musculo skeletal systems may affect what happens when treatment is not occurring such that the two measurements may be interdependent.

To overcome this potential erroneous rejection of the null hypothesis the two sets of data, were analysed separately to establish whether the patterns observed were statistically significant as independent patterns. Each of the four indicators scored during Subject ANE5's rehabilitation were analysed to establish the statistical significance of two patterns:

- Pre-treatment and During Treatment I N C D
- During Treatment and Pre-treatment I N C D

The results of the analysis included in Appendix 4.1 are summarised in Table 29. Whilst the χ^2 value is less there is still statistical significance for all patterns analysed except that recorded for Maintained Sit.

TABLE 29

Summary of Chi-square Results for Subject ANE5 df = 2 Tabulated $\chi^2 = 5.99$

Motor Task Indicator	Pre Treatment, Treatment χ^2	Treatment, Pre Treatment χ^2
Maintained Sit	10.5	5.74
Dynamic Sit	11.54	8.18
Maintained Stand	17.435	45
Dynamic Stand	14.37	9.958

This evidence would suggest that the improvement (I) observed during treatment and the loss of skill (D) observed between treatment are attributable to some process. A potential explanation of these findings will be presented in the final chapter of this thesis.

It is interesting to note that during the first two week time period there was less evidence of a fluctuating skill level in both subject ANE5 and MDG3 see Graph 8 and 9. Whilst this is insubstantial and inconclusive information it does confirm the earlier suggestion

(section 10.5.4) that the recovery of functional skills following stroke are attributable to two processes, one induced by the initial trauma and known as diaschisis, the other induced by physiotherapy and known as motor relearning.

11.6 Summary

- The pattern of '*fallbacks*' during periods of no treatment between treatment sessions was statistically significant and could not have been a random occurrence.

Evidence has been provided in the final phase of this study, that the functional recovery of motor skills occurs in a consolidation and acquisition pattern and that in 4 subjects, the consolidation phase was characterised by a statistically significant pattern of repeated '*fallbacks*' before the acquisition of the next clinically significant step in the motor task. This suggests that the repeated '*forgetting*' of the individual items of a motor skill is an essential component of the motor relearning process.

If the patterns identified during this study can be explained in the light of current knowledge of the cellular mechanisms underlying motor learning within the CNS, then evidence will have been provided of the theoretical basis of the Bobath Approach.

Evidence will then have been provided of the similarities and differences between the Bobath Approach and that developed by Carr and Shepherd, in this way establishing a theoretical basis for stroke rehabilitation.

12. THE DISCUSSION: MAKING ORDER OUT OF CHAOS.

'Physical therapists and scholars from other disciplines use theory to explain and predict phenomena relevant to physical therapy practise and to create order from chaos.'

Cruthfield et al.,(1986)

Whilst undertaking this study of functional recovery during the physiotherapy rehabilitation of stroke patients much information emerged, not only about the physiotherapy process itself but also about how the patients appeared to relearn motor control following damage to the CNS. To create order from the wealth of data provided, this discussion will endeavour to explain the findings of the study in the light of current scientific knowledge. As Schmidt (1986) suggests this will inevitably involve describing and defining *'the interrelationship between physiological, anatomical, mechanical, and pathological events'* in order to establish not only how these effect human movement but more importantly how they explain the effects of physiotherapy on the recovery of function.

The initial problem based literature review for this study identified a number of key issues relevant to physiotherapists involved in stroke rehabilitation (chapter 6). These key issues can be listed as follows:

- A lack of evidence about the effectiveness of stroke rehabilitation approaches.
- A lack of publications regarding the theoretical basis of practicing Bobath physiotherapists.
- A lack of valid measuring tools for evaluating stroke rehabilitation.
- Misinterpretation of the present state of the Bobath Approach resulting in the development of antagonisms that will limit the development of a theoretical basis for stroke rehabilitation.
- Inappropriate research designs used to evaluate stroke rehabilitation.

To address these issues the present study was undertaken. Having established the specifications for a measure of physiotherapy outcome the TELER method was chosen, and a catalogue of TELER Indicators developed and validated. During the developmental process it became apparent that the Bobath Physiotherapists involved were using a recovery model that was based on selective trunk and girdle activity. These became the clinically significant steps towards the achievement of specific functional goals, the TELER Indicators. Whilst much of this information was not new, in the authors experience this was the first attempt at formalising this clinical knowledge in the development of a functional outcome measure for use in stroke rehabilitation.

The indicators were subsequently used in a clinical setting to provide evidence of the characteristics of functional recovery and evidence of effective intervention. The purpose of this discussion will be two fold. Firstly, to present a coherent explanation of the importance or clinical significance (section 3.2.) of selective trunk activity to the recovery process. This initial discussion will include evidence in the literature of bilateral impairment of selective trunk control following a stroke, followed by the importance of selective trunk activity to postural alignment, mobility and balance.

The development of selective trunk activity in a baby will be discussed, the learning of controlled movement using trunk activity in a baby being relevant to the relearning of those activities following a stroke. An argument will be made that this initial learning process occurs not as a cognitive stage of learning at cortical level but as an automatic process predominantly controlled at cerebellar level. An argument will be made that these activities become the foundation for more highly specialised motor skills that require the three stages of learning identified by Fitts (1964). The implications of this argument will be discussed in relation to the pathology of stroke and the implementation of both the Bobath Approach and the Motor Relearning Approach developed by Carr and Shepherd et al., (1985),

Having established the theoretical basis of the developed indicators, evidence provided by the TELER Indicators when used during the treatment of stroke patients will be discussed. This evidence, regarding the characteristics of functional recovery, can be summarised into four key areas:

- the hierarchy within the developed indicators and the association between the recovery of certain motor tasks
- weekend '*fallbacks*' or loss of previously achieved items within the TELER Indicators
- between treatment '*fallbacks*' in motor achievement
- the pattern of consolidation and acquisition of motor task during physiotherapy intervention

These findings will be discussed in the light of current research in the areas of neuroscience, behaviour and biomechanics in order to establish a theoretical basis for stroke rehabilitation.

12.1 The Clinical Significance of the TELER Indicators

12.1.1 Selective Trunk Activity: Impairment and Motor Control

Bohannon et al., (1995), suggested that little work had been undertaken in relation to trunk activity following a stroke. He demonstrated (Bohannon, 1992, Bohannon et al., 1995), that trunk muscles are '*weaker multidirectionally*' in patients following a stroke and suggests that this may impair the potential for recovery.

Bohannon's studies are interesting and support the importance of multidirectional trunk muscle activity and its rehabilitation, they lack clinical validity however, as the method of data collection is inappropriate. The method of testing the '*strength*' of lateral trunk flexion entailed the use of a hand held dynamometer placed inferior to the acromion and perpendicular to the lateral aspect of the arm on the hemiplegic side. The patient was then instructed to push against the dynamometer. Similarly trunk flexion was tested by placing the dynamometer inferior to the sternal notch and perpendicular to the anterior aspect of the trunk. Again the patient was asked to push against the dynamometer.

Whilst the findings are interesting, showing a deficit between the group of patients tested and a control group, the clinical relevance of trunk side flexor activity, is in relation to the ability to shift the weight to the opposite side of the base, a totally biomechanically

different movement to that tested by Bohannon. Muscle activity in the lateral trunk side flexors are rarely used in the manner tested. However, concentric activity is required when the centre of gravity is moved towards the opposite side. At this point the side to which the centre of gravity has moved must elongate and the opposing group of muscle must contract synergically, bringing the pelvis and the shoulder closer together. This maintains the head over the base of support, ensuring postural alignment over the new base of support. If, as Bohannon's study suggests, the trunk activity is '*weakened*' then ability to move in a sitting position will be affected.

Bohannon et al.,(1995) suggest that whilst muscle activity in the limbs contralateral to the damaged hemisphere are affected, there is evidence that the limbs ipsilateral to the lesion may also be affected. (Smutok et al., 1989). Bohannon himself found that '*trunk weakness*' was not always associated with the '*limb weakness*' supporting the view that involvement of muscles may occur ipsilateral to the lesion site. The TELER indicators developed during this study include the ability to transfer weight in sitting to both sides, using selective trunk activity of both side lateral flexors.

An explanation for the ipsilateral impairment lies in the neuroanatomy of the CNS and in particular the distribution of the corticospinal and corticoreticular tracts. The corticospinal tract consists of fibres that originate in the primary motor cortex, the premotor area and the somatosensory cortex. The corticospinal tract passes through the internal capsule of the forebrain, separates in the pons and runs between the pontine nuclei before regrouping in the medulla. Kandel (1995) states that above the junction of the medulla and spinal cord only 80-85% of the tract actually cross the midline at the pyramidal decussation, descending to the contralateral dorsal part of the lateral column in the spinal cord. Lee and Donkelarr (1995) cite research carried out by Davidoff (1990) which demonstrated that 25% of the tract does not cross in the decussation supporting Kandel by stating that some cross in the spinal cord leaving 10-15% uncrossed in the anterior or lateral columns of the spinal cord. These fibres are responsible for muscle activity ipsilateral to their origin.

It has been estimated however, that the corticospinal tract has only 10^6 axons of which 330,000 are for hand activities and 330,000 end in the brain stem. This leaves only 330,000 for the rest of the upper limb, the lower limb and the trunk (Lawes, personal

communication, 1996). Whilst contributing to some impairment ipsilateral to the involved hemisphere the corticoreticular tract may be more important.

Stroke destroys approximately 20×10^6 tract fibres, many of which are corticoreticular. It is far more likely that this accounts for the clinical findings as the trunk is probably controlled by ipsilateral pontine reticulospinal fibres, in turn influenced by corticoreticular fibres. This would support the work of Bohannon et al., and Smutok et al., as well as the argument that selective trunk activity to both sides may be affected by a lesion within the CNS that affects these tracts. This evidence supports the argument that the rehabilitation of bilateral selective trunk activities must be an essential component of any rehabilitation programme for stroke patients. Furthermore, that the measurement of this process must include the recovery of bilateral activity.

12.1.2 Selective Trunk Activity and Muscle Imbalance

Having established that selective trunk activity is impaired bilaterally following a stroke and that control of selective trunk activity is, via the corticospinal and corticoreticular tracts, the importance of this activity to postural alignment, mobility and balance need to be clarified. Much of the evidence to support this argument, comes from work published, in the area of spinal manipulations used in the management of musculoskeletal pain and known in the current literature as '*muscle imbalance*' (Sahrmann, 1987; Lee, 1994; Wohlfahrt, et al., 1993; Richardson et al., 1992; Norris, 1995).

The basis of this concept is that : '*A muscle imbalance is designated as active when one of the synergistic pair of muscles predominates during an activity.*' (Sahrmann, 1987). This imbalance will result in abnormal postural alignment that in turn will lead to abnormal movement patterns (Lee, 1994) and a variety of musculoskeletal pain syndromes (Sahrmann, 1987).

Whilst much of this work is in relation to trunk flexor and extensor activity. It can be argued that the same biomechanical principles will apply to the muscles synergistic within the trunk that produce lateral side flexion with synergic elongation and axial rotation included as definitions within the developed TELER Indicators. The treatment model identified during this study involved the rehabilitation of these muscle synergies as a basis

for postural alignment, balance and co-ordinated movement when changing a base of support.

This model differs from that advocated by Carr and Shepherd (1989) where the predominant rehabilitation emphasis lies in the limb segments with little apparent consideration for the musculature of the trunk (1994b). This paper presents the '*laboratory research*' undertaken using a 4-segment model of kinematic analysis of sit stand. The purpose of this biomechanical analysis was in the authors words to, '*develop a protocol, based on a scientific framework, for optimising sit-stand performance in individuals with disability*'. The results of the study provide evidence predominantly in relation to activity at the hip, knee and ankle with little analysis or discussion of pelvic and trunk activity. The findings of the present study, supported by kinematic analysis undertaken by Nutzik et al., (1986) and Van Linden et al., (1994) would suggest that anterior pelvic control in conjunction with hip, knee and ankle control is an essential requirement of sit-to-stand.

It is interesting that a review of the only study into the effectiveness of the Motor Relearning Programme (Carr and Shepherd, 1987 a,b) presented in the original literature review (Dean and Mackay, 1992) would suggest, the majority of patients included within the study, had functional deficits in the upper limbs alone.

Most patients scored highly on the MAS item of balanced sitting and sit-to-stand. It might therefore be argued, that the Carr and Shepherd model is predominantly directed at relearning selective limb activity. This is in direct conflict with the results of the present study which would suggest that the Bobath approach involves rehabilitation of selective trunk activity as a basis for postural alignment and muscle balance.

Duncan and Badke (1987) in their book on Stroke Rehabilitation suggest that the incorrect biomechanical alignment caused by joint range limitations may '*be a primary source of abnormal postural adjustment and movement*.'

Whilst many might relate this concept to the load bearing joints of the ankle, knee and hip, of vital importance to postural alignment in the trunk are the joints of the trunk and pelvis. Indeed Carr and Shepherd (1994b), ignoring the spine and pelvis during their

analysis of sit-to-stand, do support the view that the various segments of the body being '*anatomically*' connected are also '*functionally linked*'. This might, therefore suggest, that incorrect alignment in the lower limbs will inevitably result in trunk malalignment and similarly incorrect alignment in the trunk will result in malalignment in the limbs. Both must therefore be corrected through therapeutic means.

In the same way that soft tissue shortening produces joint malalignment, muscle imbalance as defined by Sahrman (1987) will also result in a biomechanical malalignment or lack of symmetry within these structures. Whilst Sahrman suggests a variety of pathologies from the '*overuse*' syndrome of the elite athlete to the osteoporosis in women, both in turn will produce in the client group '*regional pain syndrome*'. In stroke patients the muscle imbalance is caused by damage to the CNS usually in the region of the internal capsule where the ascending and descending fibres of tracts connecting regions within the brain are closely packed (Cohen, 1993). This interruption of sensory and motor information will result in an alteration in muscle tone, bilaterally within the trunk that will inevitably culminate in the same biomechanical malalignment.

Norris (1995) suggests that muscles particularly of the '*phasic type*' that are antagonists to the postural muscles, have a tendency to '*weaken*' and '*lengthen*' with inactivity. He continues by stating that this may lead to lengthening by the addition of up to 20% more sarcomeres (Grossman et al., 1982). In the trunk the phasic muscle group, antagonists to the back extensors, are the Transversus Abdominis, Internal Oblique and External Oblique muscles. The activity of these muscles are the clinically significant items of interest in the TELER indicators as stroke patients will inevitably have muscle imbalance as described by Norris, resulting from alteration in muscle tone within postural and phasic muscles.

The conclusion of this argument, must therefore be that re-education of selective trunk activities in order to ensure appropriate synergic activity between muscle pairs, will result in the biomechanical alignment of joints within the spine, pelvis and scapulae. Using Duncan and Badke's (1987) comments regarding stroke patients this correct biomechanical alignment achieved through the relearning of selective trunk activities,

demonstrated as a model by which the Bobath physiotherapists practice, should result in normal postural adjustments and normal movement.

It must be reiterated that the Bobath physiotherapists were also identifying the need for correct alignment of the limb segments as items within the TELER indicator include clinical steps such as: *'able to take weight symmetrically through feet, able to maintain pelvis aligned over feet.'* In order to *'take weight symmetrically through feet'* the biomechanical alignment of the foot must be corrected.

In conclusion the work by Bohannon et al.,(1995) on selective trunk activity impairment, the suggestions by Duncan and Badke (1987) regarding abnormal alignment, and work on muscle imbalance in spinal manipulative therapies (Sahrmann, 1987; Lee, 1994; Norris, 1995) would appear to support the importance of this model of rehabilitation and the measurement of the recovery of selective trunk activity as an outcome of stroke rehabilitation.

12.1.3 The Development of Motor Control and Selective Trunk Activity

The rehabilitation of selective trunk activities by Bobath physiotherapists may involve the relearning of previously learned motor control. In order to establish the significance of this relearning process, evidence regarding the development of postural control in the infant must be presented and discussed in the light of the findings of this study.

During the development of motor patterns Milani-Comparetti and Gidoni (1967) suggest that some motor patterns are the result of automatic postural reactions and reflexes and that others are *'added by learning'*. This discussion will argue that these automatic responses are the foundation for task specific learning that enables the CNS to respond to changing environmental stimuli.

The argument will be made that the early automatic responses that take place during a child's development occur within subcortical levels of the spinal cord, brain stem and cerebellum before the development and refinement of higher level cognitive activities involving the cerebral cortex. These automatic responses will be identified and it will be argued that the rehabilitation or relearning of these responses in patients following a

stroke should be through these neural areas, as the patient is unable to access the cortical selective activity under volitional control. It will also be demonstrated that the muscle activity occurring in these earlier automatic responses become the components of movement in a variety of motor tasks. Life span changes in movement patterns will be presented and the suggestion will be made that the components described are available for the execution of the motor task if used within a different sequence.

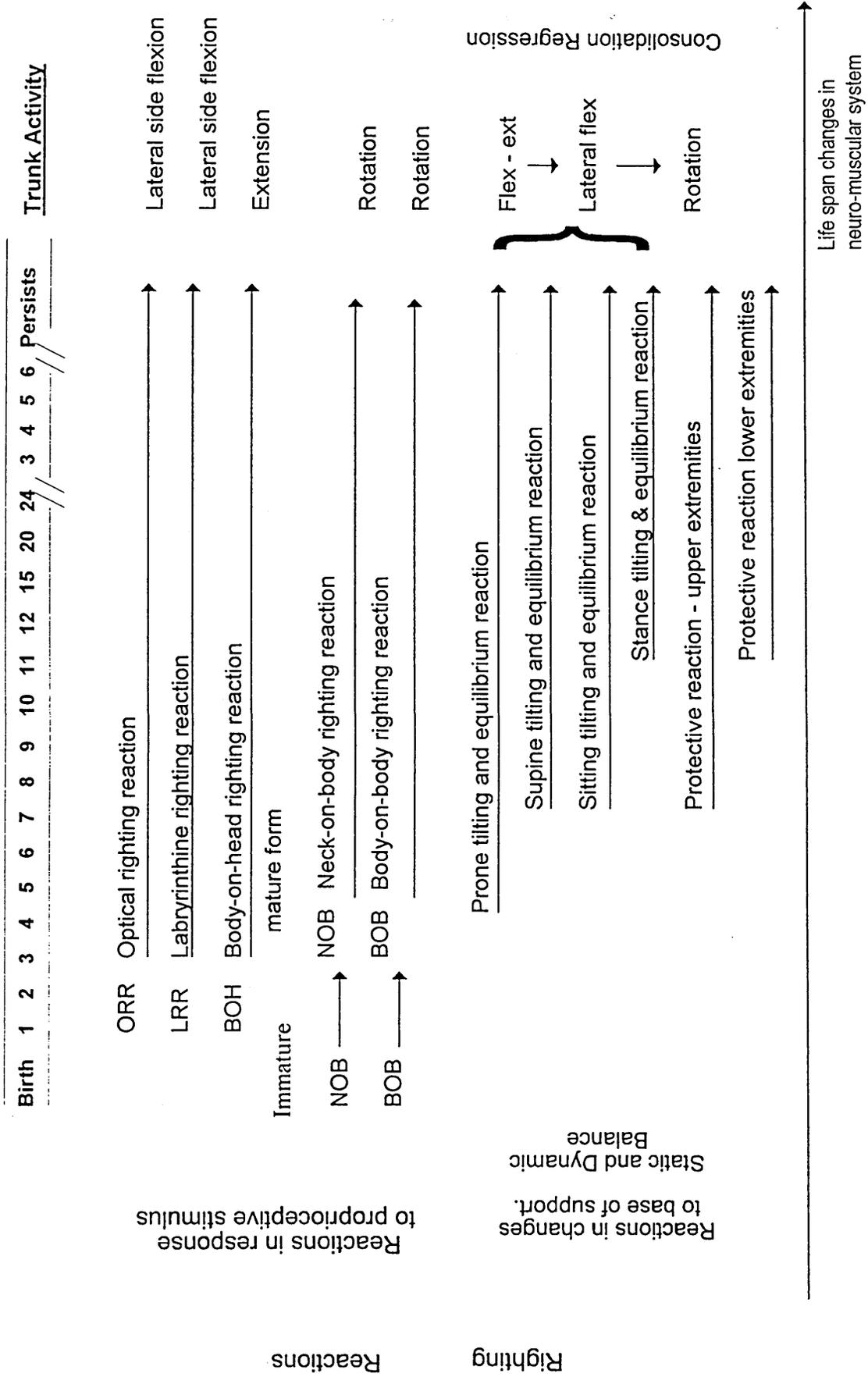
12.1.3.1 *Automatic Postural Righting Reactions*

Original theories of postural control suggested that the development of posture and movement were the result of a hierarchical process of CNS maturity, as reflexes appeared and disappeared in response to higher level cortical control over lower level reflexes (Sherrington, 1947; Magnus, 1926). However, more recent theories such as Bernstein's systems theory (1967) suggest that postural control and movement evolve from the reflex activity of the new born in response to sensory information from both the musculoskeletal and neurological systems. Milani-Comparetti (1967) was also supporting this view, when he suggested that: *'In order to acquire the progressive refinements of selective behaviour, the massive functional units of primitive reflex patterns have to be broken down into small polyvalent units available for the reconstruction of other new patterns. The child gradually acquires its full freedom of choice of movement and posture and the full repertoire of motor patterns allow him a wide variety of motor performances.'*

It will be demonstrated that these *'small polyvalent units'* are the core units of the TELER normal movement indicators (Mawson, 1995b), and that, when used to measure the recovery of motor control following a stroke, a pattern of change emerged that would suggest that a form of motor relearning was occurring. This will be supported by evidence within the literature of the cellular mechanisms of learning linking the behavioural studies in neural science with the process of physiotherapy intervention for stroke patients.

Of particular importance to this argument, is an understanding of the early development of righting reactions which Cruthfield et al., (1978) suggest *'enable a person to assume the normal stand position and maintain stability when changing position.'* The

Figure 17 Postural Development and Motor Control: The Importance of Selective Trunk Activity
 Adapted from Shumway-Cook and Woollacott, (1995)



developmental sequence of automatic postural reactions identified in Figure 17 demonstrates that these postural reflexes can be divided into reactions that occur reflexively in response to internal stimuli and reactions that occur in response to changes in the base of support.

The purpose of the righting reactions are to orientate the position of the head using visual, vestibular, proprioceptive and tactile input from the supporting surface. The purpose of the equilibrium reactions are in neurophysiological terms to maintain the head over the supporting surface or, using a biomechanical perspective, these reactions are to maintain the centre of mass over the base of support. Displacement of the centre of mass can be towards any point on the edge of the cone of stability (Shumway-Cook and Woollacott, 1995; Ragnarsdottir, 1996) this requiring a response that is similarly multidirectional.

It can therefore be seen, that the earlier righting reactions are the mechanisms by which the CNS responds and learns from external cues via the visual, vestibular, proprioceptive and tactile systems, the equilibrium reactions being the mechanisms by which the CNS learns to balance and move in response to external cues that result in alterations within the supporting surface.

Further analysis of the righting and equilibrium reactions shows that the prime moves during this developmental learning process are the synergic activities of the trunk. Figure 17, developed from the work of Shumway-Cook and Woollacott (1995), clearly demonstrates the selective activity required in both anterior and posterior, lateral, and rotational or axial trunk movements. The movements being flexion and extension of the spine and pelvis, lateral elongation and side flexion, and rotation in either flexion or extensions, upper trunk on a fixed lower trunk vice versa or counter rotation. The significance of selective trunk activity in this developmental process has been clearly identified by Mohr (1990) who for many years has advocated the rehabilitation of these activities in adult neurology as a foundation for all functional tasks.

By further studying the development of motor skills it can be seen, that these '*small polyvalent units*' (Milani-Comparetti and Gidoni 1967) or muscle activities then become '*available for the reconstruction of other patterns*' as the child rolls, moves from rolling

to sitting to crawling to standing. Appendix 5 consists of a series of drawings adapted from photographs used in Illingworth's book on normal development (1987). It can be seen from these drawings that the selective trunk activities previously discussed, are an essential component enabling the development or learning of a repertoire of movement skills, many of which are automatic in nature.

Interestingly Gesell (1946) described the development of motor milestones as being characterised by periods of '*advancement and regression*' suggesting that as a child progressed to the next stage of development they appeared to regress to an earlier form of the skill. Gesell was unable to explain this phenomena as he was looking at the development of motor control from a purely reflex and hierarchical perspective. However, using Bernstein's systems theory (1967) which suggests that movement evolves from the reflex activity of the new born in response to sensory information from both the musculoskeletal and neurological system, the complexity of the task in relation to the base of support may produce developmental pattern described by Gesell.

Whilst the baby may have developed the appropriate automatic reactions in sitting, for example using them both statically to maintain the posture and dynamically to reach for objects, turn to look in response to sounds, when placed in standing the muscles activity required to maintain the centre of gravity over the new base of support are the same in the trunk. However, the CNS has not learnt to use the '*small polyvalent units*' (Milani-Comparetti and Gidoni 1967) within the new environment hence the apparent regression identified by Gesell. This model is reflected whenever the CNS, exposed to a new base of support, is required to learn how to utilise the activities that began as reflex activity in the early stages of development.

These fundamental components of trunk activity can then be used throughout life, different individuals utilising them in different ways. Richter et al.,(1989) analysed the movement of adult rolling in 7 men and 29 women using a video camera. During 360 trials of the movement they found three common patterns: movement initiated through the upper extremities, movement initiated through the head and trunk, and movements initiated through the lower extremities. Whilst the sequence might vary, the components of selective trunk activity developed in childhood are still required, which confirms the argument that these activities are essential requirements of adult activity. In a similar

study of lying-to-standing (Van Sant, 1988) in which 32 adults were videotaped completing this movement, three common sequences were found. Again, on analysis of these sequences, subjects were using combinations of selective trunk activity, some through flexion then extension, some through flexion, lateral flexion and rotation.

This provides further evidence to support the argument that selective trunk control began as automatically learnt reactions in the baby, but that they become integrated as essential components of functional activities in adults.

In conclusion, this section has identified the importance of selective trunk activities in the development of balance and postural stability in a baby. That these are then integrated within the spectrum of movement programmes available to human beings. An argument has been made that selective trunk activities are the fundamental components required for the development of normal postural alignment and balanced movement, that they begin as reflex reactions, but that the CNS learns to use them in a variety of different environments and in response to a variety of different demands. These selective trunk activities learnt as automatic reactions in the baby, are the items within a number of TELER normal movement indicators. They were used to record the recovery of selective trunk activity, during the rehabilitation of stroke patients suggesting that this process may, in fact, represent the relearning of what was initially an automatic learning process.

12.1.4 Selective Trunk Activities and Balance

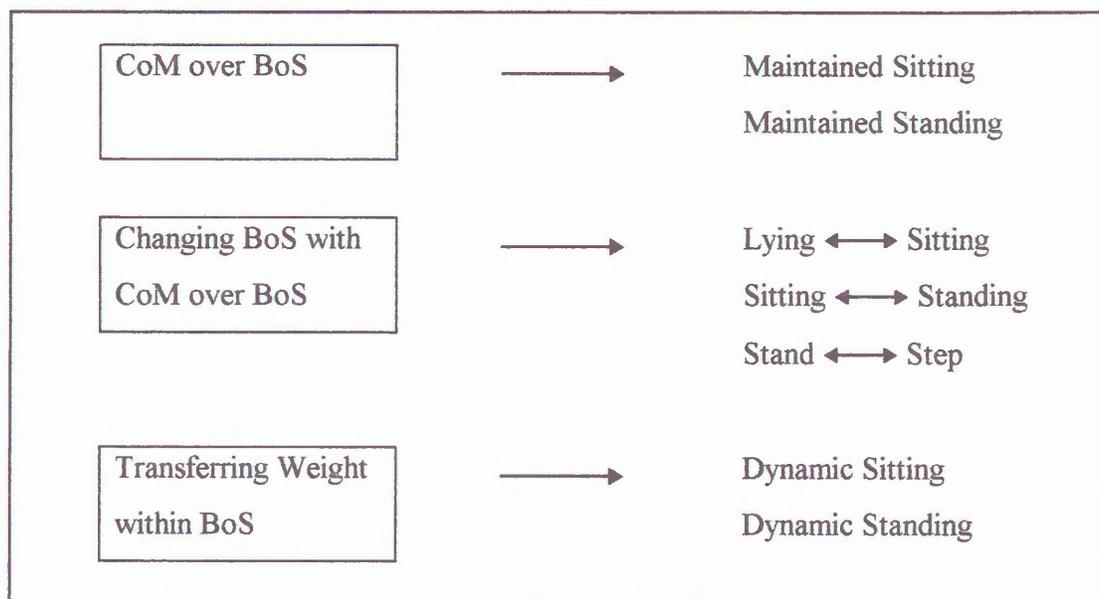
To clarify the importance of rehabilitating the muscle synergies within the trunk, the concept of balance and how the individual learns to balance requires discussion. Ragnarsdottir (1996) suggests that evaluation of the efficiency of interventions requires a measurement, and that the ability to measure a concept such as balance requires in-depth knowledge that has the agreement of all physiotherapists. Horak (1987) defined balance in terms of postural control as being: *'the ability to maintain equilibrium and orientation in a gravitational environment by keeping or returning the centre of body mass over its base of support.'* This needs further development, if used as a definition, as it precludes the concept of the integration of balance adjustments: *'into on-going voluntary movements that are the foundation of independent mobility'* (Woollacott, 1993).

Ragnarsdottir (1996), following work by Berg et al.,(1989) proposes that the balance is an 'umbrella term' used to describe four different motor skills. These motor skills being postural control during voluntary and involuntary movements, postural control on a stationary base and postural control during perturbations from outside. This suggestion enables the clinically relevant distinction between changing the base of support, such as in walking, and the weight shift that occurs when the body's base of support is not changing.

Figure 18

TELER Normal Movement Indicators

Measuring the Recovery of Postural Alignment and Balanced Movement



During the development of the TELER indicators a clear distinction was identified between the stroke patient's ability to maintain a base of support, that is keeping the centre of body mass over the existing base (TELER Maintained Sit and Maintained Stand; Mawson, 1995b), changing the base of support that is returning the centre of body mass over the new base of support (TELER Sit-to-Stand and Stand-to-Step; Mawson 1995b), and shifting weight within a base of support (TELER Dynamic Sit and TELER Dynamic Stand; Mawson 1995b) see Figure 18.

A further purpose of the balance systems identified by Rothwell (1996) is to '*stabilise the supporting part of the body when other parts are being moved.*' Looking at the TELER Normal Movement Indicators this important component has been integrated into the clinically significant steps as body alignment is followed by selective limb activity or limb placing. Whilst the concept of changing base of support has been used by others in the development of assessment tools (Parry, 1984), the TELER Indicators developed in this study are unique in their use of selective trunk and alignment to the base of support. Support in the literature, for the significance of selective trunk activity in the achievement of balance, on or within a base of support is less clear.

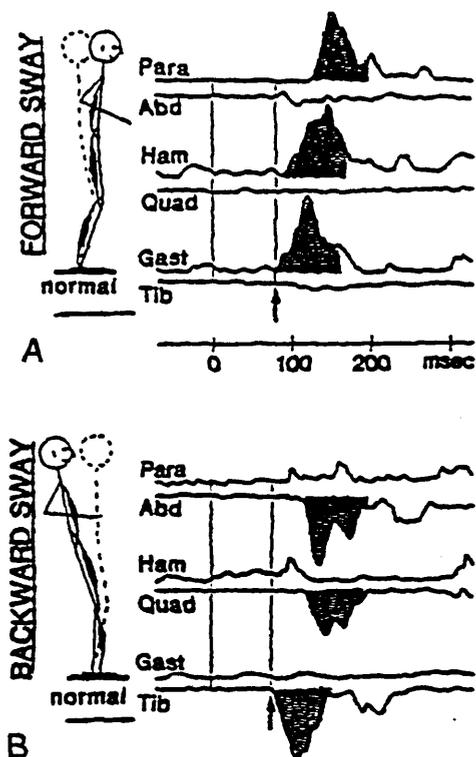
It is clear that the information received by the CNS comes from the visual, vestibular and somatosensory systems during balance. However the musculo skeletal strategies are less clear, particularly in relation to patients with a neurological impairment such as that produced by a stroke. Much of the original experimental work on postural movement strategies has been carried out by Horak and Nasher (1986) and Nasher and McCollum (1986). Horak and Nasher studied the responses in normal subjects that occurred during forward or backward displacement of the supporting surface.

As the platform moved forward the centre of Mass (CoM) was perturbed posteriorly and the response to this '*backward sway*' became known as the ankle strategy (Ragnarsdottir, 1996; Horak, 1987; Shumway-Cook and Woollacott, 1995). Similarly when the platform was moved backwards the CoM was perturbed anteriorly and the response to this '*forward sway*' also became known as the ankle strategy. See Figure 19 .

The reason for this description relates to the fact that EMG recordings of muscle contractions occurring 90 to 100 msec following the perturbation are activated in a distal-to-proximal pattern. It can be seen, however, that during '*forward sway*' the paraspinal extensor muscles of the back are activated to realign the CoM over the base of support (BoS) and during '*backward sway*' the abdominal muscles to realign the CoM over the BoS. Whilst this again supports the view presented, that selective trunk activity is a vital component of balance, this research demonstrates that when the '*floor moves*' the initial response occurs at the ankle.

Figure 19

Ankle Strategy Involved when Platform is Moved Backwards



From Shumway-Cook and Woollacott (1995)

There are two problems with this research: firstly, the floor rarely moves in relation to the body mass in a functional situation, and secondly, stroke patients invariably have problems of muscle imbalance within the hemiplegic ankle, where activation of the Gastrocnemius muscle and Tibialis Anterior muscle essential for this ankle strategy does not occur in a synergic pattern. Interestingly, further work by Horak and Nasher (1986) demonstrated that when the platform on which the subjects stood was reduced in size the responses occurring, were reversed to a proximal-to-distal pattern involving the abdominals and the back extensors.

Unfortunately this is frequently interpreted as a '*hip strategy*' (Shumway-Cook and Woollacott, 1995; Shumway-Cook and Horak, 1989) which is in fact incorrect, as a hip strategy would involve the iliopsoas hip flexor and the Gluteus Maximus hip extensor. See Figure 20

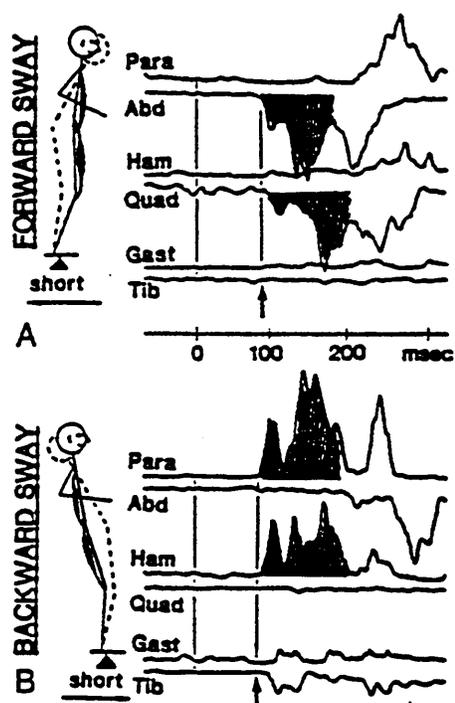
These studies therefore demonstrated that when the BoS is smaller the responses are, in fact, in the trunk. The importance of the selective trunk activity in postural control has also been suggested by Rothwell (1996) in his reporting of experiments on postural

mechanisms when the BoS is unstable. He suggests that *'when the foot cannot exert pressure against the supporting surface, arm and trunk movements are evoked.'*

This would support the suggestion that following a stroke, when the patients are unable to achieve synergic activity around the hemiplegic ankle, selective trunk activity becomes the primary mechanism for posture and balance.

Figure 20

Hip Strategy Involved when Platform Size is Reduced



From Shumway-Cook and Woollacott, (1995)

Much of this experimental research is inappropriate in relation to the clinical setting. Whilst the BoS may move in certain situations such as skiing and tube train riding, during most functional activities balanced movement occurs in response to the displacement of the CoM from an internal source, rather than an external source. When walking, for example, the movement of a lateral shift is initiated by muscle activity at the ankle. no research has been undertaken to investigate the responses occurring in the trunk. The lateral weight transference is followed by a forward perturbation of the CoM resulting from activation of one Gastrocnemius muscle. This study has demonstrated that in

standing and stepping trunk activity includes lateral side flexion with synergic elongation, anterior and posterior tilt, and axial rotation involving the paravertebral muscles and the abdominal muscles. Obviously further research is required using EMG data to confirm these findings. However, the conclusion does support the findings of this study, that selective trunk activity is essential for normal balance responses as a basis from which movement can evolve.

12.2. Developing Knowledge: Using the TELER Indicators

12.2.1 The Recovery of Selective Trunk Activity Following a Stroke: A Concept of Linked Hierarchy

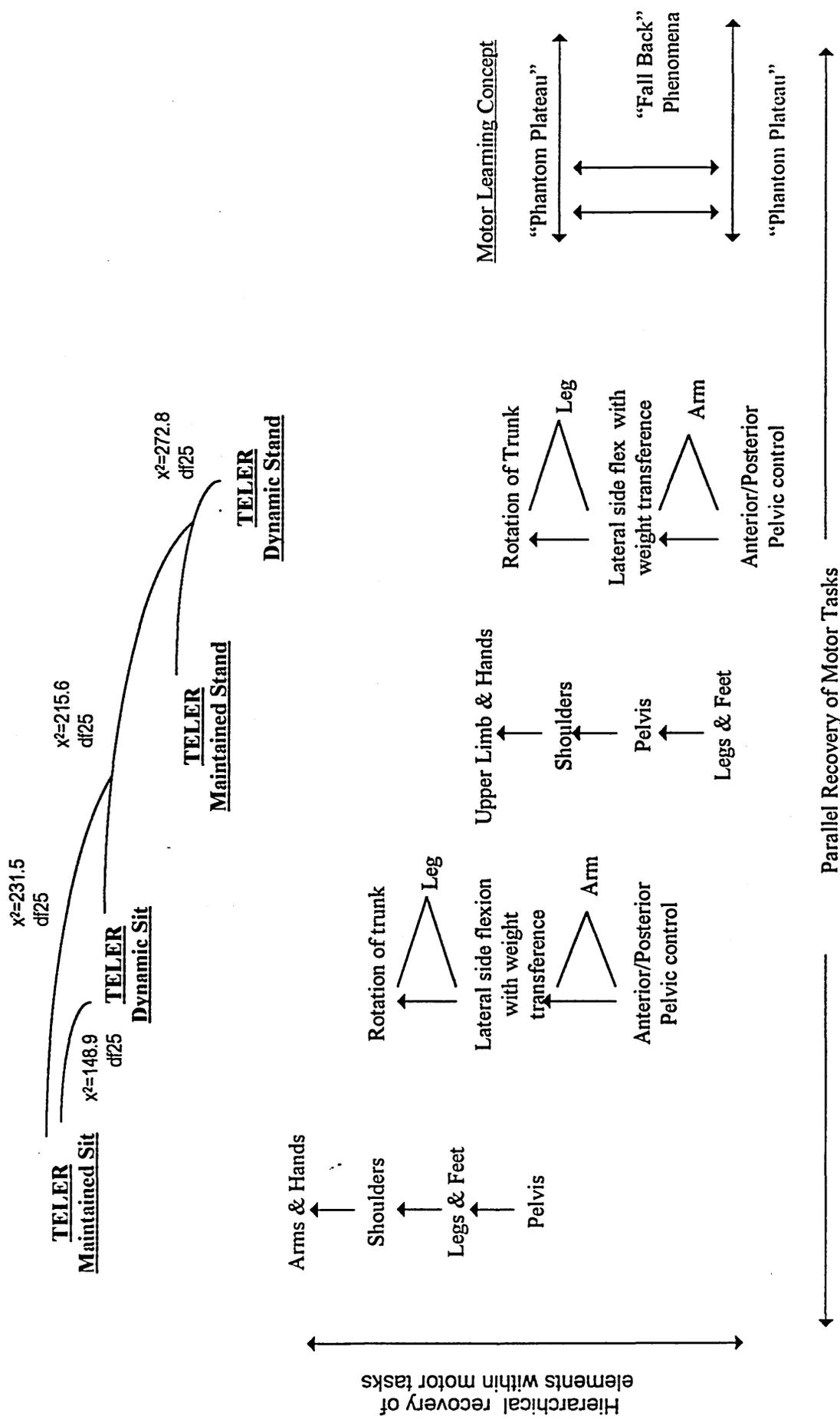
Having established the importance of selective trunk activity as both a model of rehabilitation and as definitions of a measure of rehabilitation outcomes, evidence provided of the recovery of selective trunk activity need to be discussed. Much effort in the field of psychology has been expended in an attempt to establish the exact nature of memory representations within the CNS. How these representations are sequenced is known as serial ordering and whilst much of this work (Rosenbaum, 1991; Chase and Simon, 1972) has involved '*symbolic behaviours*' such as chess playing, there have been some attempts at sequencing elements of a movement.

Of particular interest to this study is the suggestion by Rosenbaum that the most popular and well supported view is that the sequence of response occur in a hierarchical order. During the development of the TELER Indicators, a consensus was reached that the items within certain indicators were in a hierarchical order. The clinically significant steps required to achieve Maintained Sit and Stand and Dynamic Sit and Stand being placed in a hierarchical order see Figure 21.

The hierarchy of selective trunk control, corresponded with the selective trunk movement development observed in an infant, that is anterior and posterior control, side flexion and rotation (Mohr 1990). The findings of this study demonstrated that when the individual items were placed in this hierarchical order the motor tasks themselves, recovered in a staggered but parallel manner. Evidence was provided (section 10.5.5.) of

FIGURE 21

A Theory of Functional Recovery



a statistically significant association between the achievement of the definitions of the four TELER Indicators identified in Figure 21. This evidence would suggest firstly, that recovery of selective trunk activity and postural alignment on a large base of support is a prerequisite to the recovery of both on a smaller base of support and secondly, that relearning the components of selective trunk activity is not necessarily task specific as suggested by Goodgold-Edwards (1993). A relationship exists between the recovery of selective trunk activity in different motor tasks. This evidence is in conflict with Carr and Shepherd who suggest that:

'It should be noted that the regaining of balance control in sitting is not a prerequisite for standing. The alignment of the body segments to each other in sitting and standing is different and the biomechanics (and therefore the muscle activity) are also different'.

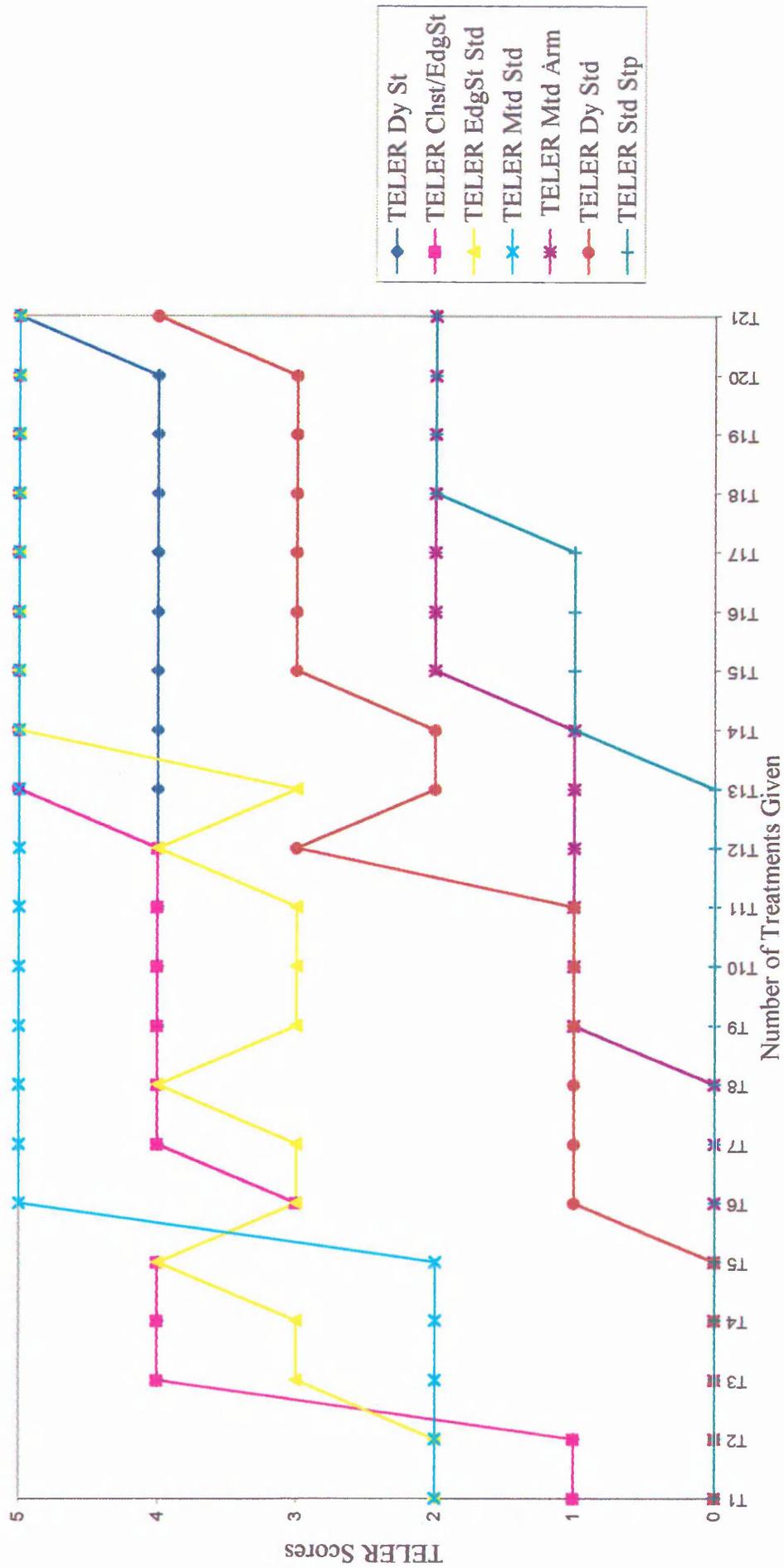
Carr and Shepherd, (1987a)

This evidence would suggest that the Bobath Approach involved both a neurophysiological and a biomechanical model of stroke rehabilitation. Mohr, (1990) in her article on the Bobath concept suggests, that experiencing selective trunk activity at a higher developmental level, that is on a smaller base of support, is a prerequisite for the recovery of selective trunk control on a smaller base of support. Evidence provided supports this assumption, the selective activity recovering in a parallel manner with statistically significant associations (section 10.5.5) between the hierarchical model when changing the base of support. Graph 10 shows the recovery of postural alignment and selective trunk activity on two different bases of support, the pelvis and the feet. The links presented in Figure 21 between the 4 motor tasks can be clearly seen in the recovery of this stroke patient.

In their book on brain injury recovery, Finger et al., (1988) pose the question of whether *'the behavioural recovery proceeds in discrete steps and stages that emulate those seen in normal development'*. Evidence provided by this study, would suggest that the pattern of recovery of selective trunk activities following a stroke *'emulates the pattern seen in normal development'*. As discussed earlier (section 12.3.1.), Gesell observed that children appeared to progress in one aspect of their development and regress in some previously learnt skill. He suggested, that the development of motor skills was not linear

Graph 10

Selective Trunk Activity: A Linked Hierarchical Theory of Motor Recovery



but followed a '*spiralling hierarch*'. During this study evidence was provided that when a patient had achieved a higher level of selective trunk activity on a large base of support this was lost for a period of '*consolidation*' when scored on a smaller base of support (section 10.5.5.) reflecting the earlier observations by Gesell and answering the question posed by Finger et al.

This evidence would support the argument that the rehabilitation of selective trunk activities in stroke patients is not only clinically significant but also that the underlying process is one of relearning.

The pattern of motor relearning observed in this study corresponds to the pattern of motor learning in a baby. Motor learning that is automatic in nature and controlled not at higher cortical level but via the cerebellum. It has been suggested (Lennon, 1996) that the Bobath Approach does not utilise motor learning, however this study to establish a theoretical basis for stroke rehabilitation has provided evidence, that the relearning of selective trunk activities underpins the implementation of the Bobath Approach. If the original mechanisms for learning these skills in a baby were automatic reactions involving not the higher cortical centres but the cerebellum, then it might be argued that this is the necessary mechanism to relearning the skills.

Evidence was provided (section 10.5.4.) that when this rehabilitation process was interrupted for more than two days the ability to achieve previously relearnt selective trunk activities was lost. These '*fallbacks*' were statistically significant for the indicators of Dynamic Sit and Dynamic Stand. It was concluded in this section that, the deteriorations (D) recorded were attributable to no physiotherapy, the memory of the activity only being maintained for short periods. This concept of short and long term memory will be discussed further in the section entitled '*The Phantom Plateau*' (12.9.) in support of the argument that repeated '*forgetting*' is part of the learning curve.

12.2.2 Motor Control: The Implications for Physiotherapy Interventions

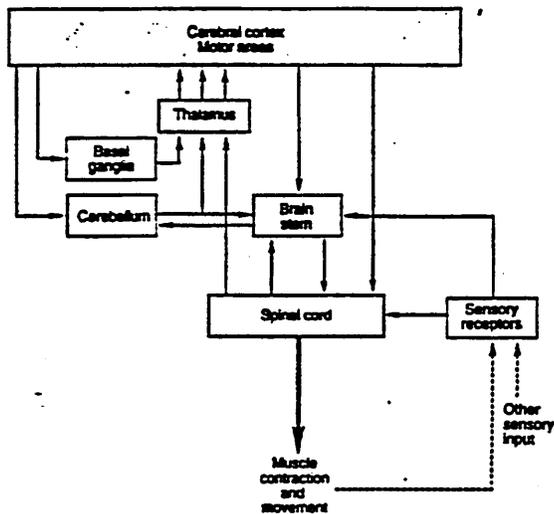
The previous section established the importance of selective trunk activities, and the link, between learning selective trunk activities in a baby and relearning them as an adult. It was concluded that this model of rehabilitation underpinned the Bobath Approach and

utilised initially automatic reactions at cerebellar level as a basis for volitional and functional skills. In order to clarify the implications this has on rehabilitation strategies, the organisation of the motor systems, with specific reference to the cerebellum, will be presented.

Kandel et al.,(1995) suggests that the motor systems use sensory information from both external and internal sources to select '*an appropriate response and to make adjustments in ongoing movement*'. The CNS is organised in both a hierarchical and a parallel way involving the spinal cord, brain stem and motor cortex hierarchically, and the basal ganglia and cerebellum as parallel systems, individually able to control movement independently of the other see figure 22.

Figure 22

Organisation of Motor Control in the Central Nervous System



From Kandel E, Schwartz J, Jessel T (1995)

Each of these components of motor control contain a '*somatotopic*' (Kandel, 1995) map of the head, body, and limbs. However, each component allows different types of movement to occur, having developed a repertoire of motor patterns in response to sensory information from both internal and external environments. Schmidt (1988) suggests that experimental work on the stages of information processing (Sanders, 1980) has demonstrated not only a serial and a parallel system of processing sensory

information to produce a motor output but also that the evidence would suggest that this is accomplished through motor programmes.

The lowest level within this motor control hierarchy is the neuronal circuits within the spinal cord and brain stem that control a variety of automatic and stereotyped motor patterns such as breathing, swallowing and walking. It was Sherrington, who demonstrated that reflex activity involving, the activation and inhibition of synergic muscle groups was controlled by neural circuitry within the spinal cord. Further work, presented in the original literature review and carried out by Grillner (1978) Forsberg et al., (1975) studied the responses in cats, when the spinal cord was cut below the level of the brain, removing the control of all higher centres. The cord, further de-afferented from below and unable to receive feedback information from the limbs, produced a rhythmical pattern of movement similar to that occurring during gait when it was electrically stimulated. These circuits have become known as Central Pattern Generators (CPGs) and whilst much of the experimental research into these circuits revolves around their involvement in gait, the scientific findings can be related to other automatic motor programmes involved in balance and postural alignment.

The significance of the CPGs to physiotherapy intervention processes can be highlighted by the experimental work using a preparation called the '*mesencephalic*' midbrain preparation sometimes called the Shik preparation after the originators Shik, Orlovskii and Severin (1966). During these experiments the spinal cord of the cat was cut in the midbrain leaving the cerebellum intact attached to '*the spinal cord side of the cut*' (Schmidt, 1988). In this situation the cat, supported on a treadmill was receiving no information from higher circuitry where perception and consciousness are located (Schmidt, 1988). The neural circuitry was then stimulated with either an electrical or chemical stimulus and the animal began to use stepping movements which continued when the stimulus was turned off. Schmidt suggests, therefore, that the CPG had been turned on by some higher source located within the midbrain and cerebellum.

The research undertaken in the present study, demonstrated that the Bobath physiotherapists involved used treatment strategies of postural alignment and selective trunk synergistic activity, in order to enable patients to relearn the motor programmes required to achieve a variety of functional tasks. Experimental work has demonstrated

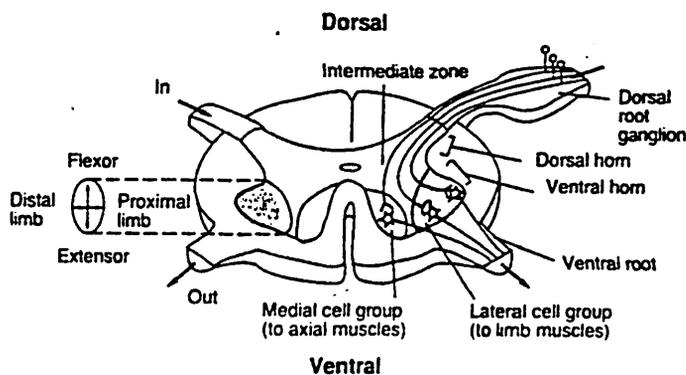
that activation of certain CPGs in cats occurs at the level not of higher cortical circuitry, but at the level of the midbrain and cerebellum and it might, therefore, be suggested that the Bobath physiotherapists stimulate the cerebellum through automatic lighting reactions as they move the centre of gravity, producing a motor programme at spinal cord level.

The significance of this, in the light of the pathology of stroke and in the light of other contemporary rehabilitation approaches will be discussed. Before this however, the anatomical relationship of the motor neurons within the mid brain and spinal cord, will be discussed in order to establish the significance of the rehabilitation of selective trunk activity by Bobath physiotherapists using nonvolitional or unconscious motor programmes as a mechanism for the rehabilitation of function.

The spinal cord is made up of a central region of gray matter containing the cell bodies and dendrites of the neurons and a surrounding white matter containing the axons of neurons. The cell bodies are grouped according to function, the medial group containing cell bodies innervating the axial muscles presented in this study, as the muscles producing the selective trunk activity. The lateral group of cell bodies within the spinal cord innervate the proximal limb muscles of the shoulder and pelvic girdles from the medial portion, and the distal muscles of the limbs from the lateral portion (See figure 23).

Figure 23

Neural Configuration of the Spinal Cord



From Kandel E Schwartz J Jessell T (1995)

Similarly groups of axons in the white matter of the brain stem are divided into those that pass medially and are concerned with the control of posture and balance through connections with the vestibulospinal tract, the medial reticulospinal tract and the tectospinal tract. These medial pathways terminate in the ventromedial part of the gray matter of the spinal cord, innervating the axial trunk and proximal girdle muscles. The lateral fibres are, according to Kandel, concerned with more goal directed movements of the hands and feet. From this review of neuroanatomy, it can be seen that the neural circuitry required to produce balance responses and postural alignment within selective trunk activity, exists below the level of the cerebral cortex and furthermore can be activated below that level.

The involvement of the cerebellum appears to be in the area of sensory-motor learning (Churchland, 1986; McCormick and Thompson, 1984). Experimental work on the eyelid response in a rabbit demonstrated that the cerebellum is essential for, and active during, the learning and retention of the eye blink response. Similarly work by Gilbert and Thach (1977), in which they recorded the electrical activity of fibres within the cerebellum in monkeys undergoing training, demonstrated that an increase in skill level was associated with changes in the firing pattern of the climbing fibres in the cerebellum. To establish the relationship between this neurophysiological function of motor learning and the role of the cerebellum as a mechanism through which Bobath physiotherapists rehabilitate stroke patients, the anatomical structure of the cerebellum will be discussed.

Whilst the cerebellum is made up of the flocculonodular lobe, the superior vermis, paravermis and cerebellar hemispheres, of particular concern to this discussion are the functions of the flocculonodular lobe and the superior vermis. The flocculonodular lobe or vestibulocerebellum, processes information from the vestibular system and appears to be involved in the regulation of muscle tone, co-ordination of head and eye movements and the maintenance of balance, equilibrium and posture through, '*the regulation of trunk and axial musculature, via the vestibulospinal tract.*' (Winstein and Mitz in Cohen, 1993). Kandel (1995) suggested, that this control is of particular importance in standing and gait.

The vermis like the flocculonodular node, has projections directly to the vestibular nuclei and, through indirect projections to the medial brain stem and cortical descending tracts,

it controls selective trunk activity and proximal girdle muscles (Kandel et al., 1995). From this it can be seen that much of the control of the trunk activity discussed earlier, and used extensively in the rehabilitation of stroke patients by Bobath physiotherapists, exists within the certain regions of the cerebellum. It might appear that the Bobath physiotherapists are addressing their handling skills directly to the cerebellum, a structure that receives information not only from the periphery but also from all levels of the CNS.

It might be suggested that the cerebellum enables the learning of normal posture, balance and alignment through the co-ordination of the righting reactions (section 12.3.1.), the fundamental link being the selective muscle activity predominantly controlled at this automatic level. The cerebellum uses information from the vestibular and visual systems and proprioceptive information from the head-on-body and body-on-head righting reactions in the baby, producing the appropriate responses within the trunk and axial musculature.

The most commonly occurring pathology is cerebral infarction, affecting 85% of stroke patients (Bamford, 1986). An infarction being the occlusion of a cerebral artery resulting in a lack of oxygen and nutrients to neural tissue supplied by the occluded artery (Royal College of Physicians, 1989). Whilst an occlusion might occur in any of the cerebral arteries listed in table 4 (section 1.2.) the most common site of occlusion in patients receiving physiotherapy is in the region of the internal capsule. This will result in damage to the corticospinal, corticostriate, corticoolivary, corticopontine, corticoreticular and corticorubral tracts, producing a loss of cortical control of sensory and motor functions.

The cerebral cortex is responsible for highly skilled, complex, voluntary movement initiated in the motor area. Like the midbrain and the spinal cord, the motor area contains a motor map of the body. However, it is significantly different in that the face and digits have a disproportionately larger representation than the trunk and girdles. Similarly a sensory map exists in the cortex with a disproportionate representation of the face and digits. Kandel (1995), states that injury to the corticospinal tract will result in the loss of individually controlled muscles of the hands and subsequent loss of skilled volitional movements used in the manipulation of objects.

The ability to initiate volitional movements is dependent not only on an intact cerebral cortex but also on the processing of information about perceptual modalities integrated within the somatosensory and associated areas of the cerebral cortex (Stern, 1993). Damage to the cortex will, therefore result in a loss of volitional skilled activities predominantly in the hands, and sensory-perceptual disorders, therefore unable to perceive verbal commands and translate them into appropriate motor responses.

It can be argued that any approach specifically targeting highly specialised cognitive activities of the limbs and involving neural circuitry above the level of the lesion will be ineffective. The Motor Relearning Programme developed by Carr and Shepherd relies on a volitional cognitive approach using verbal cues, visual feedback and, predominately limb activities with apparently little emphasis on selective trunk activity for balance, alignment and movement against gravity. During this study, it has been demonstrated that the Bobath Approach predominantly uses input-output systems that are automatic processes at the level of the cerebellum, brain stem and spinal cord, rehabilitating the basic components of balance, postural alignment and equilibrium reactions through the synergic activity of the trunk and girdles.

12.2.3 Motor Learning and the Cerebellum

Having established that the cerebellum is an important anatomical structure in the rehabilitation of stroke patients, perhaps more important in the early stages of recovery than the cerebral cortex, and having introduced the evidence in the literature, that suggest that the cerebellum is involved in motor learning, the significance of this can now be discussed in the light of the findings of the present study.

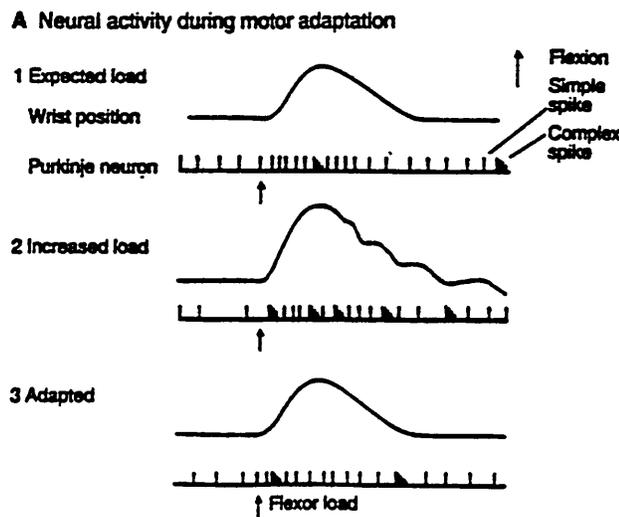
The most important experimental evidence that exists about the cerebellum's ability to learn and memorise motor skills was carried out by Gilbert and Thach (1977). In 1974 Gilbert suggested, a theory that the cerebellum exerted its effect on muscles that it was controlling by '*changing the frequencies of firing of the Purkinje cells.*' The Purkinje cells provide the only output system for the cerebellum, receiving excitatory afferent inputs from the mossy fibres and climbing fibres which both converge on the dendrites of the Purkinje cells (Kandel et al., 1995). Kandel suggests, that this synaptic connection is '*one of the most powerful in the nervous system. A single action potential in a climbing*

fibre elicits very large excitatory postsynaptic potential in both the soma and the dendrites of the Purkinje cell. Each large presynaptic potential is followed by a high frequency burst of small action potentials.'

Gilbert and Thach (1977) looked at the role of these fibres in motor learning by observing their firing activity in a group of monkeys undergoing motor training. The activity involved the flexor and extensor muscles of the wrist as the monkeys were trained to move a handle. Initially the load was kept constant and during this period, the mossy fibre evoked response was a stereotyped fluctuating simple spike recorded in the Purkinje neuron. However, in a further experiment the load was altered and the monkey's response was inaccurate until it '*learnt*' to counteract the alteration in loading. During this period, the frequency of complex spikes increased with a gradual decrease in the more simple spikes. Once the animal had learnt to anticipate the alteration in loading, the firing of the complex spikes returned to the original level. However, the simple spike activity remained below the control level. Figure 24 shows the increased neural activity in a Purkinje neuron in the cerebellum recorded, during Gilbert and Thach's motor learning experiment.

Figure 24

Motor Relearning in the Cerebellum



From Kandel et al., 1995 (adapted from Gilbert and Thach, 1977)

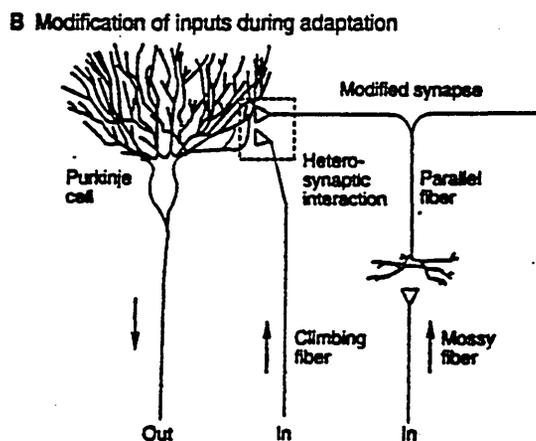
Ito (1984) took this evidence a step further, suggesting that during motor learning the climbing fibres depress the activity of the mossy fibres on the Purkinje cells, by heterosynaptic inhibition of the parallel fibres. Figure 25 demonstrates how a reduction

of mossy fibre input would result in a decrease in firing of the Purkinje cells and hence an increase through disinhibition of the output from the deep nuclei.

Kandel et al., (1995) support this view of the cerebellum's role in motor learning but asks the question '*do these cellular changes actually mediate changes in behaviour?*' It has been argued that Bobath physiotherapists communicates with the cerebellum during the early rehabilitation of stroke patients through a process of eliciting automatic selective trunk and proximal limb girdle activity, the motor activity being controlled by the medial descending systems in turn controlled by the cerebellum. That the motor programmes for balance and equilibrium specifically in standing and gait, governed by the vestibulocerebellum, may have been learnt during the developmental process when reflex activity of selective trunk muscles became integrated into functional skills.

Figure 25

Purkinje Cell Activity During Motor Learning in the Cerebellum



From Kandel et al., 1995 (adapted from Ito, 1984)

'Thus, the activity of cerebellar neurons is changed by experience and plays an important role in the learning of motor tasks.'

Kandel et al., (1995)

If evidence could be provided that a relearning process occurred during the recovery of the selective trunk muscles and that this process was attributable to Bobath physiotherapy intervention, the answer to Kandel's question might be '*yes, cellular changes similar to those occurring during motor learning in a monkey do mediate changes in behaviour in a human*'. In this way scientific evidence of motor learning

could be related to therapeutic processes occurring, as a result of physiotherapy intervention for stroke patients. Evidence has been provided that two patterns occur in the recovery of selective trunk activity, alignment and balance of post stroke patients during Bobath physiotherapy.

Using the TELER method a consolidation and acquisition pattern was recorded in 81% of all motor tasks recorded. When this was further investigated a pattern was recorded that demonstrated the relearning of a motor skill was repeatedly '*forgotten*' between treatments, this occurring within the consolidation phase, prior to the acquisition of the next clinical step in the motor task (section 11.5.). When analysed this pattern was found to be statistically significant and could not have been a random event. An explanation of this pattern can be found in the cellular mechanisms thought to be responsible for memory and learning.

To fully understand the findings of this study, a definition of motor learning is required before the cellular mechanisms responsible for learning can be identified. The argument will be made that evidence of motor relearning has taken place during physiotherapy intervention in a group of early stroke patients, explaining patterns of functional recovery recorded in the light of these cellular responses.

In behavioural terms Schmidt (1988) suggests that '*learning is a process of acquiring the capability for producing skilled action.*' He continues by stating that '*learning is the set of underlying events, occurrences or changes that happen when practice enables people to become skilled at some task.*' This concept might be modified by suggesting, that following damage to the CNS physiotherapy is the process that enables the patient to relearn the capability for producing functional movements and that the underlying events, or occurrences are the cellular changes that result in alteration in the modification of proteins at synaptic level and the synthesis of new proteins, when therapeutically guided practice enables patients to regain a functional skill. This definition of motor learning incorporates the concept, introduced in the original literature review, that changes occurring following damage to the CNS may be those of recovery, that is the regaining of pre-existing skills (Finger et al., 1988), or they may be the result of compensatory strategies that may ultimately limit the patient's potential for functional recovery (Le Vere, 1980; Held, 1993).

Whilst these underlying events of motor learning are not yet directly observable (Schmidt, 1988), evidence can be provided that motor learning has occurred by research that records the changes in appropriate behaviour or skill. During this study, the changes recorded by the TELER Normal Movement Indicators could be described, using Schmidt's definition, as the observable '*relatively permanent changes in the capability to respond.*' (1988). If these changes occur in a pattern that correlates with the known cellular mechanisms underlying learning, then this would allow the logical conclusion that the relearning of the skill during the physiotherapy intervention resulted in associated changes in '*some internal state*' (Schmidt 1988).

In order to establish whether the recovery patterns observed during the present study do represent motor relearning, the cellular mechanisms need to be discussed. In this way evidence of the theoretical basis of current Bobath physiotherapy can be established.

12.2.4 The Cellular Mechanisms of Learning

'Genes, Nerve Cells, and the Remembrance of Things Past.'

Kandel, 1989.

During the original literature review, the concept of neuroplasticity was introduced as scientific evidence has revealed the ability of the CNS to adapt in response to internal and external environmental stimuli (Gispén, 1993). Whilst numerous mechanisms of neural plasticity have been identified (Finger and Stein, 1982; Cotman and Nieto-Sampedro, 1985; Bach-y-Rita, 1980, 1981b, 1989), of particular importance to this study, are the processes whereby new neural connections are made and the effectiveness or strength of existing connections is enhanced and where abnormal connections are deleted. In this way conclusions may be drawn regarding the role of the physiotherapist when cortical control is lost following a stroke. These processes may involve the spinal cord when new connections are required. The cerebellum, when activity involving the enhancement of balance equilibrium and postural alignment is required. Both processes initially utilising automatic response, an essential component of the Bobath Approach as the loss of cortical control will result in a lack of cognitive and volitional motor planning.

The first mechanism whereby new neural connections are made involves the growth cones. These are the expanded tips of growing nerve fibre, first described by Ramon y Cajal in 1890 (Gispen, 1993), found at the ends of both axons and dendrites, that produce filopodia that protrude at random. The elongation and subsequent migration of the growth cone occurs in response to both internal and external stimuli that Gispen (1993) suggests, occur during neural development and during repair following damage. In their book on neuromuscular plasticity, Kidd et al., (1992) suggest that the chance meeting of the filopodia with lamina molecules in the extra cellular matrix guides the subsequent growth of neurons. If two filopodia meet two basal lamina molecules, the growth cone divides into two, forming two neuritic branches.

Much research has been undertaken in the area of growth cone activity, and it has become clear that the presence of local intercellular calcium plays an important role in the division of the cones to form new synaptic connections (Letourneau et al., eds, 1991). Whilst it is not the purpose of this discussion to present the complex biochemical sequences that appear to be responsible for CNS adaptations to stimuli, it is important to note that the sequence occurring during the growth and mobility of cones involves intracellular calcium, calmodulin, the activation of protein kinase C and the phosphorylation of GAP 43 (Gispen, 1991; Kater et al., 1989).

The relevance of this to the neurological physiotherapists lies in Gispen's suggestion, that many stimuli influencing neural activity affect the intracellular calcium levels. Gispen quotes work by Kater et al., (1989) which demonstrates that *'action potentials and neurotransmitter action converge at the level of the membrane potential, which in a large part determines growth cone intracellular calcium.'* Calling this their *'calcium hypothesis'* Kater et al., provide a model for the mechanisms involved in the regulation of growth cone behaviour that may indeed be the biochemical model that can be influenced by physiotherapy intervention. To develop this concept further, the factors influencing growth, loss of dendrites and inappropriate synaptic connections, needs to be discussed.

In his extensive article on the reorganisation of neural connections following trauma, Steward (1989) presents experimental evidence (Steward, 1986; Caceres and Steward, 1983) of both dendritic atrophy and regrowth as a neuroplastic concept. Of particular

interest to this study, are Steward's comments regarding the factors influencing either the total or partial loss of dendritic trees. Steward suggests that this may be the result of the speed or extent of alteration or reduction in the stimuli received by the dendrite. In a study by Liu and Liu (1971) cited by Steward, selective destruction of the innervating axon resulted in the loss of the denervated dendrites, Work by Rubel et al., (1981) would support this notion, suggesting that the early loss of receptor elements appears to prevent reinnervation. For example loss of sensory input in the auditory pathways of chickens will result in reduced stimulation of appropriate synapses and the subsequent reduction in reinnervation.

This process which occurs during neural development (Bishop, 1982) can be enhanced or reversed by environmental factors (Schapiro et al., 1970, Globus et al., 1973). Kaplan (1988) in his article on plasticity in the recovery process, cites supporting research in the cat and the monkey, in which evidence of increased cortical depth occurred following increases in stimulation. This process of degeneration of the dendritic tree is well documented by Steward (1989) who suggests, that the removal of input on the dendritic spine will result in the disappearance of the spine (White and Westrum, 1964; Colonnier, 1964; Parnavelas et al., 1974; Caceres and Steward, 1983).

In his discussion on regeneration and the restoration of function, Steward (1989) suggests that the growth or rerooting of disrupted axonal pathways (Bregman and Goldberger, 1982) can be either, orderly area-specific regeneration or disorderly area specific regeneration. In functional terms the effects of a disorderly area specific regeneration depends on the pattern of connectivity on which the required neuronal circuitry depends.

Using Kupferman's (1979) distinction of discretely organised and diffusely organised circuitry, Steward identifies the sensormotor pathways as being a discretely organised system in which neuronal circuitry is dependent on highly specific patterns of connectivity. In stroke patients following disruption of the sensormotor pathways, disorderly regeneration of this discretely organised circuitry is, suggests Steward, likely to result in disorganised function. Using Sperry's (1955) experimental work on visual responses in fish and amphibians following rotation of the eye, Steward suggests that the misdirected response on visual testing, whilst dysfunctional, does enable survival. He

concludes, that humans may be able to use inappropriate connections in an adaptive manner suggesting that patients can learn to make use of severely distorted stimuli.

This analogy is interesting, but it is in conflict with the underlying principles of the Bobath rehabilitation approach for stroke patients, where the fundamental emphasis of induced or guided CNS plasticity is the restoration of a non adaptive motor control that is the result of orderly regeneration. In a similar way to the dysfunctional fish, the stroke patient can certainly survive and sit, transfer and walk in an abnormal way. However the literature presented earlier, would suggest that abnormal behaviour may ultimately limit the patient's ability to recover pre-morbid neural activity (Le Vere, 1980 ; Held, 1993).

It is very interesting, that following his extensive presentation of reactive changes in neuronal circuitry following trauma, Steward (1989) suggests that these changes occur without intervention. He suggests that: *'the new frontier is clearly in designing intervention that promotes naturally occurring growth, induce growth that would otherwise not occur (such as axonal regeneration), or replace tissue lost (transplantation) as a result of injury or disease.'* This conclusion fails to bring into the equation either the role of the environment itself which will place demands on the damaged CNS and result in abnormal reactive behaviour at neuronal level, or the role of the physiotherapist who through therapeutic processes seeks to alter the environment perceived by the damaged CNS. In a similar way Gispen (1991) clearly sees the relevance of calcium in the process of CNS plasticity but in suggesting pharmacological manipulation of calcium levels, fails to acknowledge the role of therapies in the biochemical process.

A clinical application of this concept can be seen, in any stroke rehabilitation department when a stroke patient who has been allowed to walk abnormally with associated reactions in the upper limb loses the ability to use the arm in functional balance or feeding, dressing and manipulatory skills such as key board operation. The development of associated reactions in response to a lack of postural control alignment and selective trunk activity in standing are the result of disorganised regeneration and reconnection of the sensorimotor circuitry.

If the biochemical calcium sequence presented earlier, and the concept of disorderly regeneration are accepted, then this may explain the compensatory abnormal responses that occur in stroke patients who do not receive physiotherapy. Thinking back to the discussion of levels of motor control, it will be remembered that following a stroke, cortical control is lost to a varying degree. The spinal cord sensorimotor circuitry and indeed the CPGs are potentially isolated from cortical control, and respond only to stimuli received from the brain stem and the periphery. Without physiotherapy input, the information received at spinal cord level and indeed at brain stem level may be inappropriate and distorted. It might be hypothesised that by providing normal sensory stimuli during the physiotherapy process, the intracellular calcium model proposed by Kater et al., (1989) is stimulated and growth cone behaviour is guided to achieve more organised regeneration of neuronal circuits within the spinal cord.

Whilst an interesting hypothesis and worthy of further research, of more significance to this study, are the changes in the efficacy of communication between neurons at the synapse thought to be responsible for memory and learning. In order to establish the links between the biochemical processes involved in neuroplasticity and the physiotherapy process an understanding of the cellular mechanisms of learning and memory at synaptic levels is required.

Shaw et al., (1993) in their review of the origins of synaptic neuroplasticity states that intense electrical stimulation increases synaptic transmission and that this phenomena known as long-term potentiation (LTP). This is thought to be related to mechanisms underlying some forms of learning (Barnes et al., 1992). Shaw cites numerous studies on animals that have demonstrated the mechanisms involved in LTP and whilst these are all confined to the hippocampus and the visual cortex, Steward (1989) in his discussion of neuroplasticity following CNS trauma states: *'comparative studies demonstrate that when given examples of reorganisation have been compared across species, if normal circuitry is compared, the growth responses have been comparable.'* In other words, if the neural structure and biochemistry is the same then the evidence might be extrapolated to human subjects. The existence of LTP in humans and in areas other than the hippocampus and the visual cortex has now been confirmed by a number of studies on patients with amnesia (Square et al., 1993)

Theories of how the learning process changes neuronal structures in the CNS are of particular importance to stroke physiotherapists, as the motor skills and patterns of movement learnt during normal development, may require to be relearnt following trauma. The fundamental outcome of effective physiotherapy intervention, is the relearning of pre existing motor tasks as opposed to the learning of new movement strategies that may inhibit recovery. Whilst the mechanisms underlying both memory and learning are thought to be the same (Kupfermann, 1991; Kandel, 1989; Kandel et al., 1995) exactly where this learning takes place and where the memory of motor skills is localised is less, clear, although it has been identified in the earlier discussion that the cerebellum plays an important role in the storage and retrieval of motor activities.

Many of the early experimental studies of memory stem from the original work begun in 1885 by Herman Ebbinghaus. It was Ebbinghaus who designed a simple experiment that enabled him to investigate how new information was stored in the brain. Using a set of '*nonsyllables*' (Kandel, 1989) which he subsequently memorised at a rate of 50 words per minute Ebbinghaus generated two basic principles of learning:

Firstly, that memory skills are graded and that practice improves the level of memory, and secondly, the more complex the learning task the more repetitions of the learning process are required.

Taking these principles a step further, James (1980) first proposed two distinct processes in the storage of memory, a short term process which he called primary memory, and a long term process which he called secondary memory. This idea was subsequently supported by experimental work undertaken by Muller and Pillemer (1900) from which they hypothesised that following learning, a certain amount of time is required for this new information to become a '*consolidated*' memory. Following Muller and Pillemer's work a number of further experiments reviewed by a number of authors (Hilgard, 1940; McGeogh, 1952) on both animals and human subjects have confirmed this original theory.

To establish what the mechanisms were behind these two learning processes, Kandel (1989) developed a series of experiments using the reflex behaviour of the invertebrate *Aplysia* which he suggested was comparable to the neuronal circuitry involved in the

defensive withdrawal reflex of the vertebrate. Kandel stated that these reflexes can be modified by sensitisation and other forms of learning such as habituation, classical conditioning, and operant conditioning (Carew, 1981; Carew et al., 1983; Hawkins, 1985).

Whilst the biochemical sequences involved in the learning process are complex, a number of important features of the process need to be highlighted. Firstly, Kandel demonstrated that a short-term memory which has a time course of minutes to hours involves the modification of pre-existing proteins and that the acquisition of long-term-memory that lasts more than one day may depend on the induction of new proteins initiated by second messengers involved in short-term memory. Further experimental work on Aplasia (Hawkins et al., 1983; Walters and Byrne, 1983) has indicated that the mechanisms for modifying pre-existing proteins and enhancing pre-synaptic facilitation in classical conditioning of the gill-withdrawal, siphon-withdraw and tail withdraw is activity-dependent.

This activity-dependent presynaptic facilitation, like the mechanisms involved in the growth of cones appears to be calcium dependent. Kandel et al., suggest that the resultant CAMP cascade of the classical conditioning in the Aplasia may be the building block of more complex forms of learning.

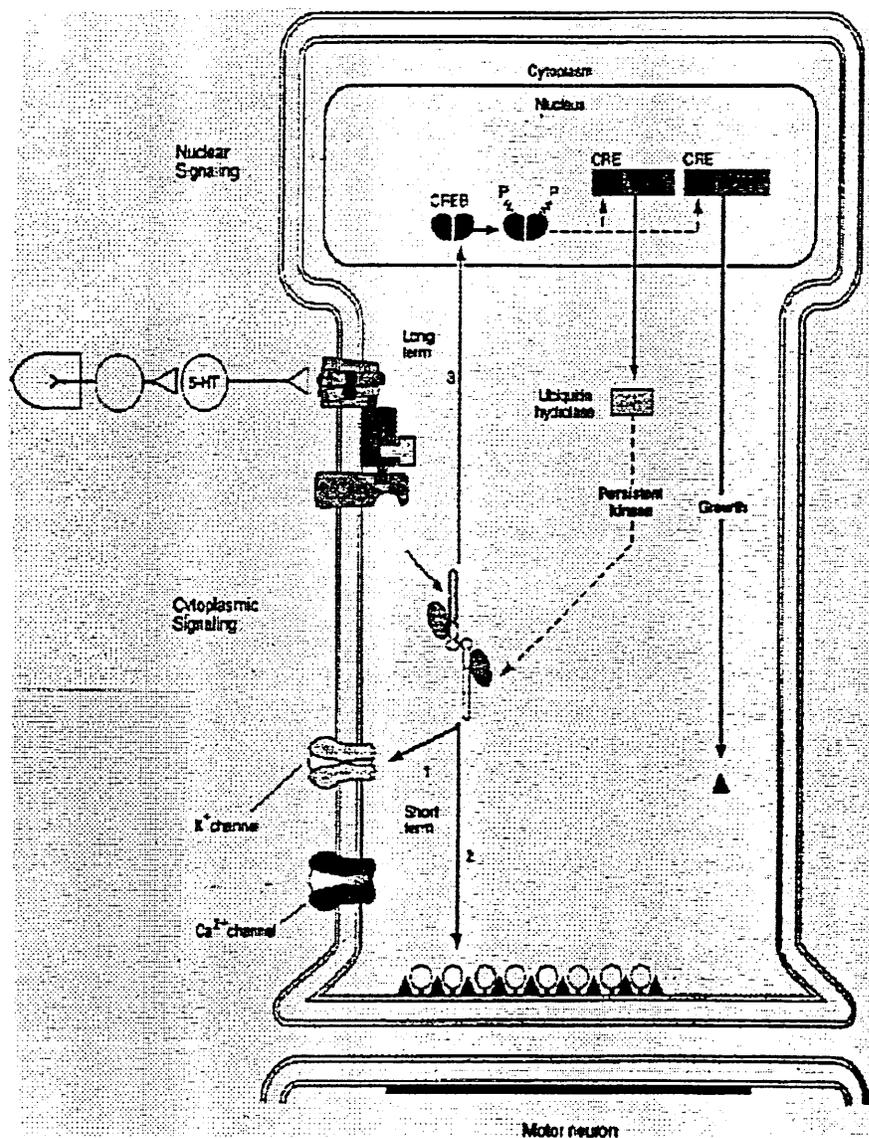
Whilst the work by Kandel and others (Hawkins et al., 1983, Abrams et al., 1984) on the sensori-motor synapse of Aplasia demonstrated a cellular mechanism responsible for short-term learning lasting '*minutes to hours*' (Kandel et al., 1995) of significant importance to the results of this study are the experimental studies that suggest, a second linked mechanism is responsible for long term learning that lasts days or weeks and known in the literature as Long Term Potentiation (LTP) (Bliss and Collingridge, 1993; Shaw, 1994; Gispén, 1993; Kandel et al., 1995).

The experimental work on LTP has involved two types of invertebrate neurons, the mammalian hippocampus and cortex (Bliss and Collingridge, 1993) and in the visual cortex of the cat (Komatus et al., 1991). Because of the similarities in the circuitry of the hippocampus and the cerebellum, the studies of LTP as a mechanism of information storage (Gispén, 1993) will be discussed. As with the presynaptic facilitation of sensory

neurons in Aplasia, the biochemical sequences thought to take place in the hippocampus are complex. (See figure 27).

Figure 27

Cellular mechanisms involved in Long Term potentiation in the Hippocampus



From Kandel, E Jessell T and Schwartz J (1995)

Like the earlier cellular mechanisms, LTP is a calcium-dependent process and does not require the synthesis of new proteins. A number of studies suggest that, the depolarisation of the post-synaptic membrane that results from a tetanic stimulation of glutamine dependent synapses in the hippocampus removes Mg^{2+} from the Ca^{2+} channels coupled with the glutamate receptors. This results in the influx of Na^+ , and Ca^{2+} through the channels, increasing the Ca^{2+} levels within the dendritic spine, triggering the calcium-calmodulin kinase and kinase C cascade that produces LTP. Kandel et al., (1995)

suggests, that retrograde messengers possibly nitric oxide and carbon monoxide, two gases that readily diffuse through cell membranes, diffuse back to the pre-synaptic terminal to activate a second messenger which then, by enhancing transmitter release, maintains the LTP. Arachadonic acid has now also been found to be a retrograde messenger responsible for enhancing transmitter release (Lawes, personal communication 1996).

The final link in this jigsaw of short and long term learning appears to involve the regulation of gene expression from within the nerve cell nucleus. Brinton (1993) in his chapter on learning and memory, describes the relevant genes as being '*immediate early response genes*' similar in configuration to the previously discovered protooncogene. Brinton suggests that following the activation of the two kinases, cyclic AMP-dependent kinase and Calcium / Calmodulin-dependent kinase, they enter the cell nucleus inducing gene production that is likely to involve learning and memory. Supporting this hypothesis Brinton cites research on Vasopressin (Brinton, 1990) that has been found to induce two early response genes in the hippocampus, suggesting that:

'we can safely say that this class of genes plays a key and pivotal role in communication between events occurring at or near the cell membrane and events occurring in the nucleus that will have long-lasting consequences for the function of the neuron'

Brinton, 1993

It can therefore be seen that there are three distinct and interrelated biochemical processes involved in learning and memory in scientific studies carried out on animals. Experimental studies on monkeys has also provided evidence of increased neuronal activity within the mossy fibres and climbing fibres of the cerebellum during motor learning. In discussing reorganisation mechanisms in the CNS, Steward (1989) suggests, that where circuitry is the same across species the cellular responses are the same (Steward and Messanheimer, 1978; Geddes et al., 1985). It is therefore highly likely that mechanisms demonstrated in animal studies are those occurring in more complex circuitry involved in the learning of movement skills where the synaptic structure is the same. Two logical conclusions can therefore be made: firstly, that the cellular processes that have become known as neuroplasticity must accompany the increased activity in the

cerebellum recorded during motor learning in a monkey and secondly, that both these phenomena can be assumed to be the process by which motor learning can occur following a stroke in human beings.

Returning to Schmidt's concept that motor learning itself cannot be observed rather the achievement of the activities that represent that learning, it has already been argued in this discussion that the items included within the TELER normal movement indicators constitute the items of motor learning following a stroke and that they can be scored during physiotherapy intervention, to establish the pattern of recovery occurring over time. It has also been argued that the items or codes of particular interest within TELER indicators are the items recording the recovery of selective trunk activity, girdle active and postural alignment and that these movements are controlled via the cerebellum as automatic responses occurring during normal balance and movement.

Logically, therefore, the pattern of recovery recorded by these TELER indicators following the loss of cortical control resulting from a stroke, may provide evidence of motor learning at cerebellar level if the pattern reflects the cellular processes identified. Evidence has been provided that the repeated '*fallbacks*' recorded in the recovery of selective trunk activity during physiotherapy intervention were attributable to intervention.

The pattern of repeated between treatment '*fallbacks*' prior to a new motor skill acquisition, clearly demonstrated in graph 8 and 9 (section 11.5.), may theoretically represent the short term cellular changes which require to be repeated before the more long term and permanent changes can take place. The repeated '*forgetting*' of a learnt skill is an integral part of the relearning process. The pattern recorded providing evidence of an association between the '*underlying cellular mechanisms of learning*' and the process of effective physiotherapy intervention.

12.2.5 The Phantom Plateau

Is a motor learning curve a curve without plateaus ?

During the original literature review, the concept of a '*plateau*' was introduced as being a period of consolidation or no change in the acquisition of a skill. Plateaus were described in the literature by Kuhn (1970), who suggested that they occurred during the progressive development of knowledge or during the relearning of a motor skill. Bachy-Rita and Balliet (1981a) suggested that consolidation phase represented a period of time in which the patient was unable to learn new material. They further suggested, that an acquisition consolidation pattern occurred as the patient learnt during the rehabilitation process to put together the '*individual components of a movement*' (Bachy-Rita, 1981 b) into a smooth co-ordinated automatic action that takes place outside the rehabilitation setting. He recommended research into the phenomena, suggesting that it might lead to '*considerable therapeutic benefits*' not in terms of explaining the intervention process, but as a means of managing the patient during periods of no change.

It might be remembered that Acheson-Cooper and Saarinen-Rahikka (1986) also suggested the concept was worthy of research as this, she felt, might provide valuable information about '*neuroplasticity*' occurring in the CNS. Prior to this view Twitchell (1951) had described the recovery pattern of 121 post stroke patients suggesting that a plateau occurred at the end of an episode of care when following no improvements, the patient was discharged. This conflicting view of both the features of a plateau and the value of their investigation will be discussed in the light of the findings of the present study.

During phase III, a '*step and plateau*' or consolidation-acquisition pattern of recovery was recorded in the achievement of 129 TELER indicators, this being 81% of the total goals scored during physiotherapy intervention. In the developmental second phase the same pattern was recorded in 45% of functional goals scored, the total patient numbers for both studies being 69. As discussed earlier this pattern is in conflict with the research undertaken by Partridge (1991, 1987) in which a linear pattern was recorded. However, the studies' inclusion at this point serves to highlight the literature supporting the research findings and those which do not.

It was also noticed that during this consolidation-acquisition pattern, recovery of items included within the TELER indicator were interrupted at times by periods of no

treatment. Further investigation of the dates included on the TELER form revealed that these periods of no treatment were, in fact, weekends lasting frequently longer than two days. These findings will be discussed further, in an attempt to provide evidence that the patterns of change recorded were attributable to physiotherapy intervention and not to random occurrences.

Whilst this study is limited to a non-random sample of 69 acute stroke inpatients, and the findings cannot be inferred to any larger sample, they have provided evidence that the relearning of the components of a motor task, such as sit-to-stand and walking, do occur in a consolidation-acquisition pattern as suggested by Bach-y-Rita and Balliet (1981 a). These plateaus occur during the episode of care and not at the end, as suggested by the earlier work of Twitchell (1951).

However, during a further search in the literature for an explanation of this phenomena, a paper was uncovered entitled '*The Phantom Plateau*' (Keller, 1958). In this article Keller describes the original teaching about the '*learning-curve-plateau*' observed in research into the learning of Morse-code at the turn of the century (Bryan and Harter, 1897, 1899). Bryan and Harter demonstrated that periods of '*no advancement*' occurred in the learning curve that represented periods '*in which word habits have not yet become sufficiently automatic for progress with phrases and sentences to take place.*' Rosenbaum (1991) formalising Bryan and Harter's findings suggests that these plateaus represent the repetition of information before it can become a '*memory unit*'.

Keller suggests, however, that this original work was flawed in a number of ways, one of which was the method of testing the research participants. He continues by citing work by Tulloss (1918) and further supporting work by Cook (1957) in which a more appropriate training and testing process was used. The results of this work on the learning curve suggested that '*progress went on quite steadily for each kind of material there are ups and downs, but nowhere do we find the classical plateau.*' Whilst happy to prove once again that the learning curve was truly a curve, '*the amount of improvement from one trial to the next decreases as the number of trials increases*' (Keller, 1958) the researchers paid little heed to the '*ups and downs*' for individual subjects, or to the effects of averaging across subjects, which would smooth out the plateaus of individuals. Links were not made at the time between short term and long term learning, probably

because scientific knowledge about the pre-and post-synaptic changes occurring during learning, were not available as an explanation, or indeed as a research concept.

This presentation highlights the importance of deciding what the measurement variables are and when they are to be measured. The previous authors, basing their studies on existing knowledge, were looking at disproving the theory of plateaus in learning. However, the purpose of this study was to investigate the recovery or relearning process itself. During the study, clinicians involved became aware that whilst the scores recorded by the independent observers were the maximum achievement during the treatment session, patients frequently returned to the department having lost previously gained skills.

Mathiowetz and Haugen (1994) suggests that the performance changes occurring during physiotherapy are only temporary, and '*thus do not reflect learning*' as in Schmidt's definition learning requires there to be a '*relatively permanent change in the capability to respond*' (Schmidt, 1988). This is an unusual argument, as it suggests that anything that is forgotten was never learnt. Indeed it may very well be the process of repeated forgetting that results in the more permanent changes in the capability to respond. To investigate this concept 4 patients were scored by independent scorers during the physiotherapy intervention and also on their return to the department prior to their next physiotherapy session.

In this study to establish the theoretical basis for stroke rehabilitation, evidence was provided that between treatments the patient lost the ability to achieve a particular item or code on the TELER indicator. It might be argued that this repeated '*forgetting*' prior to the acquisition of the next code was a reflection of the normal learning process and that the ability to maintain the achievement over a clinically significant time period should be included within the codes of the TELER indicator.

The '*ups and downs*' described by Tulloss (1918) and Cook (1957) in the learning curve were repeated in this study of the recovery of motor skills, however they existed within the '*phantom plateau*'. In the light of the current knowledge of cellular mechanisms of learning and memory discussed earlier, this new pattern can now be explained as being evidence of motor relearning.

Following Schmidt's (1988) suggestion that research into motor learning must be designed to record changes in motor behaviour, it might be logically concluded that the achievement of a clinically significant item or code on the TELER indicator during physiotherapy intervention is associated with an increase in synaptic efficiency. Because this increase at synaptic level is known to be of varying duration from minutes to hours and days to months, depending on the cellular area involved, it might be argued that the pattern recorded during this study represents short and long term motor learning.

The repeated '*fallbacks*' within a plateau were statistically significant and therefore attributable to a lack of physiotherapy intervention. They appeared to be a prerequisite for the acquisition of the next item within the motor task, the previous item becoming a '*relatively permanent changes in the capability to respond*' Schmidt (1988)

The items of interest defined within the TELER indicators were those developed to record the recovery of axial and limb girdle control, the functional significance of this being the patient's ability to maintain postural alignment and balance dynamically on varying bases of support. This aspect of motor control has been demonstrated to occur predominantly at subcortical level and in particular within the cerebellum. As experimental evidence exists that motor learning does occur within the cerebellum it might be logically assumed that the pattern recorded is a reflection of cerebellar activity.

During the analysis of the findings of this study it was conclusively demonstrated that the pattern of '*fallbacks*' occurring between treatments was not a random pattern but attributable to some process. It is interesting to note that patients A NE5, and MDG3, in graphs 18 and 19, appeared to have no '*fallbacks*' within the consolidation phase of their motor recovery, during the initial two to three weeks post stroke. To attempt an explanation of these findings it is important to refer back to the original literature review regarding spontaneous recovery and the theory of diaschisis.

Many of the original articles reviewed suggested, that spontaneous recovery is attributed to all changes in functional status during the first three months following a stroke. However, looking at the graphs, it can be seen that two distinct patterns appear to occur

following the stroke: one during the initial three week period and the other subsequent to this period.

Spontaneous recovery is the term applied to the processes within the CNS that occur in response to an injury. The earlier review suggested that spontaneous implied random events an inappropriate term or recovery that is in fact not random, but a response to injury. By definition therefore spontaneous recovery should be denoted by improvements in the clinically significant steps of the TELER indicator. Because this pattern is recorded during physiotherapy intervention it is impossible to identify whether this pattern is the result of spontaneous recovery or recovery induced by intervention. However, the second pattern appears at two to three weeks and is markedly different, the patient improving and deteriorating within a consolidation plateau.

Spontaneous recovery implies improvement or compensation. The deteriorations occurring during recovery, as discussed, represent the repeated forgetting of a movement skill and cannot be attributed to spontaneous recovery. These repeated '*fallbacks*' must therefore be attributed to intervention. The question still remains as to whether the pattern observed is attributable to physiotherapy, or to other input from the stroke team.

To establish this more clearly the fallbacks at the weekends which appeared to interrupt the learning process need to be discussed. Work by Muller and Pilzecker in 1900, reviewed by Kandel (1989), suggested that during the consolidation phase of learning the long term memory process is '*sensitive to disruption*' (Kandel, 1989). During the analysis of these fallbacks it was demonstrated that some of the fallbacks were not random events and therefore attributable to some change in the patient's environment. During the weekend period whilst the patients may receive input on positioning from the nursing staff, they do not receive treatment directed specifically at the dynamic components of balance and mobility. This may explain why the relearning of maintained sitting and standing did not appear to be interrupted by a weekend break as the patients were still receiving input from nursing staff.

The interruption of learning represented by these fallbacks might logically be attributed to physiotherapy, and occupational therapy if this was specifically addressing the recovery of selective trunk activities.

During the initial two to three week period following a stroke, when it might appear that the recovery occurs as a result of natural physiological responses, it has been suggested that physiotherapy has little value. Whilst neuroscientists such as Shaw (1993) and Steward (1989) suggest a critical time period when cellular processes may become disorganised, they suggest that these disorganised events occur without intervention. Whilst it is true that this is without therapeutic intervention, it is in response to information received from the sensory systems.

During the initial time period regrowth and the development of circuitry takes place in a random manner that is indiscriminately and without order. The selection of appropriate circuits is the result of demand, that is the environment selects the random connections. Unless the patient is in a persistent vegetative state the CNS will be attempting to make sense of information from Golgi tendon organs, tactile proprioceptive input from weight bearing surfaces, visual and vestibular systems, all in the absence of integration from the cortex. It might be suggested that the physiotherapist's role at this stage is to modify and guide the sensory information, ensuring that the synaptic activity and development of connections between synapses are not disorganised and random, but organised and appropriate. This will enable the recovery of motor components and motor skills to the pre-stroke level, and prevent the compensatory strategies which might develop in a disorganised circuitry and limit the potential for further normal recovery.

12.3 A Grand Model of Stroke Rehabilitation

If this argument attributing the motor learning to physiotherapy intervention is accepted, an explanation is required of how the physiotherapy process might be achieving this relearning process. There are a number of key areas to this discussion of effective physiotherapy intervention: the use of appropriate afferent pathways, the biomechanical realignment of musculoskeletal structures, the use of automatic reactions and the use of repetition and knowledge of results (KR). Whilst these will be considered individually, ultimately they will all provide sensory input to the CNS whether this be intrinsic or extrinsic (Schmidt, 1988) as it is this constant demand on the CNS that produces the dynamic change within neural structures known as neuroplasticity. To reinforce this concept it is necessary to return to Gispin's (1993) definition of neuroplasticity as being :

'the capability of the neuron to adapt to changing internal or external environment, to previous experiences or to trauma.'

Gispén W, 1993

What may be the difference between approaches such as Carr and Shepherd and Bobath are the different afferent stimuli used. As discussed earlier, the Bobath physiotherapist uses afferent stimulation involving the spinal cord, the vestibular system and the cerebellum, whereas the Motor Relearning Programme of Carr and Shepherd uses afferent stimulation of the motor cortex via auditory and visual pathways.

The earlier discussion regarding muscle imbalance and soft tissue shortening concluded, that the re-education of selective trunk activity by Bobath physiotherapists, in conjunction with soft tissue manipulations ensures the appropriate synergic activity between muscle pairs and the correct biomechanical realignment of joints within the spine, pelvis and scapulae. This will inevitably provide sensory information from the periphery which provides the intrinsic information that contributes to motor learning (Shumway-Cook and Woollacott, 1995). In this way the Bobath physiotherapists are utilising the biomechanical systems to rehabilitate the CNS.

The use of automatic reactions as a mechanism for motor learning is perhaps one of the most fundamental concepts of the Bobath approach. Whilst physiotherapists working in the area of spinal manipulation for musculoskeletal problems such as *'regional pain syndrome'* (Sahrmann, 1987) may use techniques of muscle strengthening and facilitation of selective trunk activity to improve the patient's functional levels, they tend to use resisted exercises to achieve this goal (Lee, 1994). Bobath physiotherapists attempting to achieve the same goal recruit trunk activity by moving the centre of gravity in a variety of different directions within the cone of stability described by Ragnarsdottir (1996). This produces an automatic balance reaction that can then be incorporated within a functional task.

The pathophysiological significance of working at subcortical levels in the rehabilitation of patients, who have had a stroke has been discussed with particular reference to other contemporary rehabilitation methods, which may be less successful with acute patients.

In this way it can be seen that the Bobath physiotherapist is integrating the neurophysiological responses to biomechanical alterations in the centre of gravity learnt during the development of motor control as an automatic process within the cerebellum.

In numerous behavioural studies the use of knowledge of results has been an important factor contributing to motor learning (Shumway-Cook and Woollacott, 1995; Schmidt, 1988). This form of extrinsic feedback provides the patient with information about the outcome of the goal itself, as opposed to knowledge of performance (Schmidt, 1988) which informs the patient about the performance itself. The patients involved in this study, by virtue of the fact that the TELER system was used to evaluate their progress were involved in goal planning and knowledge of performance.

Whilst the physiotherapist had subdivided the goals or motor task into clinically significant component items, the patient inevitably received feedback about their success both during the treatment session and at the end. Winstein (1991) reinforces the use of this behavioural concept suggesting that: *'This information serves as a basis for error correction on the next trial and thus can be used to achieve more effective performance.'* Whilst this concept has been attributed to the rehabilitation approaches of the cognitive models (Carr and Shepherd, 1994b) physiotherapists using the Normal Movement Indicators (Mawson, 1995b) within the TELER system (Le Roux, 1995 a,b) must be utilising this concept, as the fundamental assumptions of the approach are that it is patient specific and based on clinically significant change.

Information provided by this study demonstrate that the Bobath physiotherapists were using repetition of activities to promote motor learning. (See graph 15) Stephenson (1993) in his review of neuroplasticity cites a number of animal studies (Towe and Mann, 1973; Held, 1987; Goldberger and Frank, 1981) that demonstrate that both previous experiences and repetition affect long-term changes within the dendritic trees. The relevance of this to the physiotherapist is that the therapeutic process is specifically aimed at the rehabilitation of previously experienced motor skills and not necessarily new tasks. The argument has already been made that the storage of these motor programmes are within the cerebellum and spinal cord, repeatedly accessing them via automatic reactions to displacement being the domain of the Bobath physiotherapist. Whilst certain authors (Lee et al 1991) suggest that repetition is synonymous with cognition. This is, in

fact, not necessarily the case as this study has demonstrated that repetition of automatic responses results in motor learning as a relatively permanent ability of the patient to respond to disturbances of their centre of gravity.

Whether this ability is transferable is a controversial issue. Carr and Shepherd suggest that the practise and repetition of one action, may not transfer into another biomechanically different action, implying that this underlying assumption of the Bobath approach is flawed:

'it is therefore unlikely that practise of one action will necessarily generalise into a better performance, biomechanically different, action. This must make us question the assumption that therapeutic exercise will carry over to improved function. Similar criticisms can be directed at the use of so-called 'neurodevelopmental sequence'. This notion has played a dominant role in therapeutic intervention in the last few decades.'

Carr and Shepherd 1994b

This present study has been about the recovery of selective trunk activity as a basis for correct postural alignment, balance and mobility, the TELER indicators being predominantly about the recovery of sitting, standing and walking. In their book on the motor relearning programme for stroke patients (1987a) Carr and Shepherd state in relation to balance training:

'The retraining of balance in sitting and standing requires that the patient experiences these positions. That is, he will not regain the ability to stand until he is in the standing position. It should be noted that the regaining of balance control in sitting is not a prerequisite for standing. The alignment of body segments to each other in sitting and standing is different and the biomechanics (and therefore the muscle activity) are also different.'

Carr and Shepherd, 1987a

The results of this present study are in total conflict with this observation as the component items, within the TELER indicators of Dynamic Sit/Dynamic Stand and

Maintain Sit/Maintain Stand were found to be linked, the sitting components being a prerequisite skill for the achievement of the more advanced standing.

An important concept of transfer identified by Shumway-Cook and Woollacott (1995) relates to the similarity between tasks. Work by Lee (1988) would suggest that, the more similar the task the more likely the transfer. It has been argued that the ability to maintain postural alignment and move dynamically within a base of support requires not only ankle, knee and hip strategies but, more importantly, trunk strategies. This synergic activity within the trunk involves the ability to control the centre of gravity over the base of support when movement or perturbation occurs within a multidirectional cone of stability.

During the developmental sequence referred to by Carr and Shepherd, these reflex reactions became integrated within a variety of motor programmes available for the achievement of a variety of functions. The components are the same, the environment in which the programmes require activation may alter as the base of support changes.

It has been argued in this discussion that, following a stroke, a patient may lose the ability to achieve symmetrical postures due to abnormalities in tone and perception that may themselves, lead to musculoskeletal abnormalities. It has also been argued that these patients will have trunk muscle imbalance. If a patient has muscle imbalance when positioned on a large base of support such as sitting, it must be logically assumed that this will be reinforced when they are in a biomechanically more compromised position such as standing, with its smaller base of support. The argument must therefore conclude that, the achievement of trunk muscle balance in sitting is a prerequisite for muscle balance in standing, unless of course the treatment regime allows for compensatory activity within the trunk.

In attempt to establish the links between the behavioural sciences, biomechanics and neurosciences there would appear to be some similarities between contemporary approaches and some fundamental differences. Much of the work undertaken in the field of behavioural science and cognition in relation to motor control has looked at the development of highly skilled learnt behaviours such as playing the piano, playing tennis,

typing (Lee, 1991; Schmidt, 1988) and learning complex codes in training of Morse code skills (Keller, 1959). It has been established in this discussion that much of this activity occurs at cortical levels as much of this work has involved normal subjects. Certain contemporary therapists, such as Carr and Shepherd, rightly took this evidence and knowledge and integrated it into their model of intervention in order to achieve motor learning.

As presented earlier, much of their work appears to involve the re-education of highly skilled activities at a cortical level. Carr and Shepherd (1994) suggest that therapists are movement scientists. However, they fail to appreciate that, whilst this is inevitably so, movement scientists study normal movements; physiotherapists are movement scientists who have a knowledge and understanding of abnormal pathologies. The skill of a physiotherapist is therefore the integration of movement science into medical science in order to provide a rehabilitation approach, aimed at restoring normal movement, following the damage or destruction of neuronal circuitry.

In their book Carr and Shepherd suggest that:

'The unique contribution of physiotherapy to the rehabilitation of stroke patients lies potentially, in our view, in the retraining of motor control based on an understanding of the kinematics and kinetics of normal movement, motor control processes and motor training.'

Carr and Shepherd, 1987a

The findings of this study would suggest, that this concept is limiting in its view of stroke rehabilitation, as their kinematic analysis fails to establish the fundamental significance of trunk synergistic activity as a basis for all movement skills, or the significance of stroke pathology in relation to the neuroanatomical structures controlling these basic motor programmes. Without this integration of all the sciences, physiotherapists may be attempting to *'talk'* to neural tissue that *'cannot hear'*; rather, the physiotherapist must use this knowledge to communicate with neural tissue that can respond. Neural circuitry that *'responded'* during the development of motor control early in life. Neural circuitry that was able to *'respond'* before the development of the human species, before the

cortex had evolved, the flocculonodular lobe of the cerebellum the phylogenically oldest region of the central nervous system.

12.4 Limitations of Study and Future Research Development

Whilst the initial phase of the present study, involved the development of TELER indicators, these indicators were limited to the identified needs of acute stroke patients and those managed within Stroke Units. The needs of late stroke patients and those managed within the community environment may be different. Environmental and psycho-social factors may necessitate the use of compensatory strategies rather than recovery of normal motor control.

Similarly the study was about the recovery of function following a stroke; however, physiotherapists working in the field of neurological rehabilitation may be treating patients for whom the primary intervention goal may be the maintenance of functional skills prior to deterioration in neurological status. With this group of patients the pattern of consolidation prior to acquisition of functional skills, may be inappropriate. The goal of intervention strategies being the maintenance of plateau or periods of no change prior to deterioration. Whilst the aim of the physiotherapists involved in the present study was to shorten the plateau, the aim of the physiotherapist in certain patient groups might be rather to lengthen a plateau, maintaining the patient's functional status. This different model of outcome may be pertinent for patients for example with multiple sclerosis, motor neurone disease, or a cerebral tumour.

The study was limited to the investigation of early functional recovery, identifying predominantly TELER Indicators that measured changes in Impairment and Disability. However, indicators recording changes in the patient's level of Handicap (WHO IDH Geneva, 1980) are of equal importance for neurological patients, particularly young head injured clients.

The purpose of the study was to establish a theoretical basis for stroke rehabilitation by investigating not only the physiotherapy process, but also the characteristics of functional recovery. Evidence of attribution was provided by the TELER method, the question still remains however, regarding the factors contributing to this attributed change, for

example, what role do other members of the multidisciplinary team have in this process of rehabilitation?

Because of these limitations, further research involving, firstly, the National Special Interest Group, the Association of Physiotherapists with a Special Interest in Neurology (ACPIN), and secondly, the nursing professions and other Professions Allied to Medicine (PAMS) must be implemented. Collaboration between these groups would result in the development of Multidisciplinary Neurology TELER Outcome Indicators that, having 'Face' validity, could be further validated during neurological rehabilitation in a variety of environmental settings. Use of the TELER method by a number of different professions would provide evidence of the relationship between multidisciplinary team outcomes.

Following the identification of problems within the area of stroke rehabilitation the present study has provided some evidence, not only of the Bobath physiotherapy process, but also of the characteristics of effective physiotherapy rehabilitation for stroke patients. Whilst it has highlighted some of the flaws in other contemporary approaches such as that developed by Carr and Shepherd (1987a, 1987b, 1989), it has also highlighted similarities between the two approaches. The MAS developed by Carr and Shepherd could be converted into TELER indicators and a study involving the Motor Relearning Programme in Australia and the Bobath Approach in the UK could then be evaluated. The present study suggested that Carr and Shepherd (1989) appear to work with patients who have higher levels of cognitive and functional ability (Dean and MacKay, 1994) than those included in the present study. An argument being made that the Australian method may preclude certain patients by virtue of their level of initial impairment. If an international study were undertaken this issue would require investigation either with inclusion and exclusion criteria or, far more relevant clinically, a retrospective analysis could be undertaken of the impairment levels of the patients treated in both groups. The TELER method would provide information about the patterns of recovery occurring during both treatment approaches.

Whilst some information has been provided about the reliability of the TELER Indicators this, as discussed earlier, is limited and interrater and intra-rater reliability requires testing. It must be stated that the measure itself is reliable. However, the measurers may not produce reliable results as their level of knowledge may vary. A study is under way

in Norway to establish the reliability of the TELER Indicators developed during the present study which will hopefully include physiotherapists with differing levels of postgraduate education.

Evidence has been provided that two patterns of recovery occur during physiotherapy intervention. A consolidation and acquisition pattern and a repeated '*fallback*' pattern when the patient is unable to carry over a motor ability from one treatment session to the next. The concept that repeated '*forgetting*' is, in fact, part of the relearning curve requires further research. Evidence regarding the number of '*fallbacks*' prior to acquisition, would be valuable information for service managers and purchasers as the number of repetitions is a direct reflection of physiotherapy cost. Ways of establishing how many repetitions and factors affecting the numbers required would provide valuable information for resource allocation and comparison of results nationally.

During the discussion of the significance of selective trunk activity to the balance and postural alignment mechanisms, it became apparent that much of the moving platform experiments (Horak and Nasher, 1986) and Bohannon's (1995, 1992) muscle strength testing using a goniometer were not only inappropriate but limited in the range of balance direction tested. EMG studies are urgently needed to confirm the clinical findings of the present study, which has suggested that abdominal and extensor activity, lateral trunk flexor synergy's, and rotation are all required in both balanced and aligned sitting, standing and walking. During these future studies perturbation of the CoM must occur as a result of an internal initiation of balance responses as opposed to an external disruption of the BoS. In this way the research would more clearly reflect the requirements of the balance and postural mechanisms in functional movement.

12.5 Summary

Following the development and validation of a series of TELER Indicators that fulfilled the theoretical basis of the Bobath Approach, they were subsequently used to investigate the physiotherapy process and the characteristics of functional recovery.

The item of specific interest within some of the indicators were the selective trunk activities documented within certain Bobath literature. Using the developed outcome

measure in acute stroke rehabilitation resulted in the provision of evidence ($p < 0.05$) that an association existed between the recovery of selective trunk activity on differing bases of support, the recovery patterns observed reflecting the pattern of automatic motor learning in a baby. It was therefore, logically concluded that the rehabilitation of these activities reflected the automatic relearning of motor skills.

The motor control of automatic trunk activity and axial synergy's are predominantly located below cortical level, the cerebellum being largely responsible for trunk and limb girdle control. Evidence in the literature has confirmed, that motor learning does occur in the cerebellum and that the cellular mechanisms of short and long term potentiation are implicated as one of the mechanisms.

Further evidence was provided that functional recovery occurs in an acquisition and consolidation pattern and that these were characterised by repeated '*fallbacks*' or loss of previously acquired skills. The association between these '*fallbacks*' and periods of time between treatments was statistically significant ($p > 0.05$) and it has been argued that this pattern reflects the short and long term cellular mechanisms of memory and learning.

Therefore the model of intervention used by Bobath physiotherapists to initially facilitate automatic trunk activity results in motor relearning at cerebellar level as a prerequisite for volitional activity. This model whilst similar to that developed by Carr and Shepherd in the use of internal and external cues, repetition and knowledge of results, differs in two specific areas:

- the rehabilitation of selective trunk activities as a foundation for all functional activities.
- the use of motor relearning at cerebellar level prior to the use of volitional cortical motor relearning.

It was argued that cognition was not a prerequisite for motor relearning as the original learning of selective trunk control in a baby is an automatic process that enables the subsequent development of more specialised cognitive learning. The baby learning by movement, developing motor programmes that can then be integrated into all functional activities.

The pathophysiological and neuroanatomical implications of a stroke may result in patients who are unable to use cognitive motor programmes, an estimated 45% of stroke patients having perceptual and spatial deficits following damage in the region of the internal capsule. For these patients the use of an approach such as, the Bobath Approach may be more beneficial than cognitive motor relearning advocated by Carr and Shepherd.

12.6 Conclusion

The recovery of function following a stroke involved a hierarchical, parallel process of selective trunk and limb girdle activity, relearned by repetition of automatic activity, that theoretically involves short and long-term cellular mechanisms. This hierarchical, parallel recovery occurred in a consolidation-acquisition pattern superimposed upon which were repeated '*fallbacks*' in the ability to achieve some items defined within the TELER Normal Movement Indicators. Whilst the process was activated by automatic responses, this led to the use of volitional skilled movements during physiotherapy as the automatic processes became integrated into functional tasks.

An argument was made that the focus of rehabilitation in the initial phase is through the cerebellum which in turn feeds information to the cerebral cortex and to the spinal cord. In this way the Bobath physiotherapists are '*talking*' directly to the cerebellum and the spinal cord, the sensory input guiding the cellular mechanisms towards organised connections and appropriate synaptic communication. Hence, it may be concluded that:

- The Bobath physiotherapists talk to cells that can listen so that they can talk to each other.
- During physiotherapy the motor relearning curve is not a curve, it is rather a series of hierarchical and parallel processes that recovery in a consolidation and acquisition pattern superimposed with repeated fallbacks that represent changes in the internal cellular state of the neural structures involved

This study has not only identified the characteristics of effective physiotherapy intervention for acute stroke patients, but it has also provided a theoretical basis from which physiotherapists and researchers can move forwards in the development of

informal and formal knowledge. The study has established some of the similarities and differences between the Bobath Approach as it is used in clinical practice, and the approach developed in Australia by Carr and Shepherd, moving towards a clearer understanding of the use of motor relearning in stroke rehabilitation.

It is hoped that this knowledge will dispel some of the myths and misinterpretations regarding the Bobath Approach used in the United Kingdom and in the United States of America. It is anticipated that publication of the findings of this study, will facilitate collaboration and development between approaches rather than antagonisms which have inevitably limited the growth of neurological rehabilitation internationally.

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APPENDICES

Appendix 1

- 1.1 The TELER Form
- 1.2 National Institute of Stroke Scale
- 1.3 List of Stroke Units Involved in Phase II
- 1.4 Data Collection Form Phase III

Appendix 2

- 2.1 List of Indicators Produced During Phase II
- 2.2 Characteristics of Patients Involved in Phase II Including Frequency of Plateau Pattern
- 2.3 Developmental Process to Satisfy the Theoretical Basis of the Bobath Approach.

Appendix 3

- 3.1 Protocol for Phase III Data Collection Exercise
- 3.2 Clinical Standards for the TELER Indicators
- 3.3 Motor Assessment Scale Criteria for Scoring
- 3.4 General Rules for Administering the MAS
 - 3.4.1 MAS Score Sheet
- 3.5 Barthel ADL Index Scoring Form
- 3.6 Guideline for Barthel Index
 - 3.6.1 Barthel Index Score Sheet
- 3.7 Data Collection Forms for TELER Scores
- 3.8 Characteristics of Patients Involved in Phase III
- 3.9.1. Chi-square analysis used to test for associations in chapter 10
- 3.9.2. Chi-square analysis for 5 randomly selected patients used in Phase III analysis

- 3.9.3. Rank correlation analysis used to assess the validity of certain TELER and MAS scores
 - 3.9.3.1. Chi-square analysis to establish whether the TELER Indicator of Sit to Stand was more responsive to change in Motor skill ability than the MAS.
- 3.9.4. Chi-square analysis to establish whether between treatment 'fallbacks' occurred in the recovery of a series of TELER Indicators for 1 subject A NE5 and 4 subjects including A NE5.
- 3.10 Rank correlations and Strength of Agreement for 29 Patients in Phase III
- 3.11 Rank Correlations for Specific Indicators Validated in Phase III

Appendix 4

- 4.1 Analysis of 4 TELER Indicators Scored during the Treatment of Subject A NE 5 in Phase IV

Appendix 5

- 5.1 The Development of Selective Trunk Activity in a Child

Appendix 6

- 6.1 Publications by Author

Goal: _____
Indicator: _____
0: _____
1: _____
2: _____
3: _____
4: _____
5: _____

Goal: _____
Indicator: _____
0: _____
1: _____
2: _____
3: _____
4: _____
5: _____

Goal: _____
Indicator: _____
0: _____
1: _____
2: _____
3: _____
4: _____
5: _____

Goal: _____
Indicator: _____
0: _____
1: _____
2: _____
3: _____
4: _____
5: _____

Goal: _____
Indicator: _____
0: _____
1: _____
2: _____
3: _____
4: _____
5: _____

Goal: _____
Indicator: _____
0: _____
1: _____
2: _____
3: _____
4: _____
5: _____

Goal: _____
Indicator: _____
0: _____
1: _____
2: _____
3: _____
4: _____
5: _____

APPENDIX 1.2

NIH STROKE SCALE

Highlighted items denote those assessed in patients included in this study.

<u>Test</u>	<u>Scale</u>	
Level of Consciousness	0 1 2 3	Alert, keenly responsive Drowsy, but arousable by minor stimulation to obey, answer or respond Requires repeated stimulation to attend, or lethargic or obtunded requiring strong or painful stimulation to make movements (not stereotyped) Responds only with reflex motor and autonomic effects, or totally unresponsive, flaccid, reflexless
Level of Consciousness: Questions	0 1 2	Answers both correctly Answers one correctly Answers both incorrectly or unable to speak
Level of Consciousness: Commands	0 1 2	Obeys both correctly Obeys one correctly Incorrectly
Motor Arm	0 1 2 3	Limb hold for 90° for full 10 seconds Limb holds 90° position but drifts before full 10 seconds Limb cannot hold 90° position for full 10 seconds but there is some effort against gravity Limb falls. No effort against gravity
Motor Leg	0 1 2 3	Leg holds for 30° for a 5 second period Leg falls to intermediate position by the end of the 5 second period Leg falls to bed by 5 seconds, but there is some effort against gravity Leg falls to bed immediately with no effort against gravity
Limb Ataxia	0 1 2	Absent Ataxia is present to one limb Ataxia is present in two limbs

Dysarthria	0 1 2	Normal Mild to moderate: patient slurs at least some words, and at worst can be understood with some difficulty Patient's speech is so slurred as to be unintelligible (in absence of, or out of proportion to , any dysphasia)
Language	0 1 2 3	Normal Mild to moderate, as follows: naming errors, word-finding errors, paraphasias, and/or impairment of comprehension or expression disability Severe: fully developed Broca's or Wernicke's aphasia (or variant) Mute or global aphasia
Sensory	0 1 2	Normal, no sensation loss Mild to moderate: patient feels pinprick is less sharp or is dull on the affected side or there is a loss of superficial pain with pinprick, but patient is aware of being touched Severe to total sensation loss. The patient is not aware of being touched
Neglect	0 1 2	No neglect Visual, tactile or auditory hemi-inattention Profound hemi-inattention to more than one modality
Extraocular Movements	0 1 2	Normal Partial gaze palsy, score is given when gaze is abnormal in one of both eyes but where forced deviation or total gaze paresis is not present Forced deviation or total gaze paresis not overcome by the oculocephalic manoeuvre
Visual Fields	0 1 2	No visual loss Partial hemianopia Complete hemianopia
Facial Palsy	0 1 2 3	Normal Minor Partial Complete

Adapted from Brott et al (1989)

APPENDIX 1.3

Stroke Units Recruited for Phase II

Northern General Hospital, Sheffield

St George's Hospital, Lincoln

Mansfield Community Hospital, Mansfield

Nether Edge Hospital, Sheffield

Tickhill Road Hospital, Doncaster

APPENDIX 1.4

Data Collection Form Phase II

Patient Code and Location

Time Frame:

T.I.A. < 24 hours

Minor Stroke > 24 Hours < 1/52

Major Stroke > 1/52

Rankin Handicap Score (Total Handicap)

- 0 No symptoms
- 1 No significant disability despite symptoms: able to carry out all usual duties and activities
- 2 Slight disability: unable to carry out some previous activities but able to look after own affairs without assistance
- 3 Moderate disability: symptoms which significantly restrict life style and/or prevent totally independent existence (eg requiring some help).
- 4 Moderately severe handicap: symptoms which clearly prevent independent existence though not needing constant attention (eg unable to attend to own bodily needs without assistance)
- 5 Severe handicap: totally dependent, requiring constant attention day and night.

Adapted form Rankin (1957) Cited in Wade D T (1992(c)).

APPENDIX 2.1

First Delphi Round Phase II

Functional tasks requested by stroke patient during assessment process prior to treatment

Indicator Name:

Location:

* Sit to stand	Mansfield Community Hospital
* Independent stand	Mansfield Community Hospital
* Assisted step	Mansfield Community Hospital
* Independent side step	Mansfield Community Hospital
* Independent forwards step	Mansfield Community Hospital
* Assisted sit to stand	Mansfield Community Hospital
* Assisted stand	Mansfield Community Hospital
* Assisted step	Mansfield Community Hospital
* Independent sit to stand	Mansfield Community Hospital
* Independent side step	Mansfield Community Hospital
* Independent forward step	Mansfield Community Hospital
* Independent sitting	Mansfield Community Hospital
* Assisted sit to stand	Mansfield Community Hospital
* Assisted stand	Mansfield Community Hospital
* Assisted step	Mansfield Community Hospital
* Independent side step	Mansfield Community Hospital
* Independent forwards step	Mansfield Community Hospital
* Independent sitting	Mansfield Community Hospital
* Sit to stand	Mansfield Community Hospital
* Assisted stand	Mansfield Community Hospital
* Side step	Mansfield Community Hospital
* Independent forward stepping	Mansfield Community Hospital
* Independent sitting	Mansfield Community Hospital
* Sit to stand	Mansfield Community Hospital
* Assisted stand	Mansfield Community Hospital
* Walking	Mansfield Community Hospital
* Transfer sit to stand	St Georges Hospital, Lincoln
* L Hip and knee control	St Georges Hospital, Lincoln
* Gait	St Georges Hospital, Lincoln
* Transfer bed to chair	Northern General Hospital
* Walking with a rollator	Northern General Hospital
* Independent toileting	Northern General Hospital

* Independent stairs	Northern General Hospital
* Sitting to lying	Northern General Hospital
* Sit to stand	Northern General Hospital
* Stand to sit	Northern General Hospital
* Transfer bed to chair ass1	Northern General Hospital
* Walk 10 paces with ass1	Northern General Hospital
* Walk with stick and supervision	Northern General Hospital
* Sit to stand ass1	Northern General Hospital
* Lying to sitting	Northern General Hospital
* Sit and dress upper body	Northern General Hospital
* Sit to stand	Northern General Hospital
* Stand to sit	Northern General Hospital
* Independent walking	Northern General Hospital
* Transfer bed to chair ass1	Northern General Hospital
* Independent drinking	Northern General Hospital
* Independent rise walk and sit	Northern General Hospital
* Walking outside	Northern General Hospital
* Independent stairs with rail	Northern General Hospital
* Independent drinking	Northern General Hospital
* Independent transfer	Northern General Hospital
* Independent walking 20 paces	Northern General Hospital
* Independent toileting with a stick	Northern General Hospital
* Sit to stand with assistance	Northern General Hospital
* Roll and sit up	Northern General Hospital
* Ass stand	Northern General Hospital
* Ass sit to stand	Northern General Hospital
* Ass stand to sit	Northern General Hospital
* Ass walking 5 paces	Northern General Hospital
* Independent transfer	Northern General Hospital
* Independent transfer with compensation	Northern General Hospital
* Rise form the floor	Northern General Hospital
* Sitting	Northern General Hospital
* Sit to stand ass1	Northern General Hospital
* Ass stand	Northern General Hospital
* Sitting	Northern General Hospital
* Ass stand	Northern General Hospital
* Ass sit to stand	Northern General Hospital

* Standing	Northern General Hospital
* Ass step	Northern General Hospital
* Sit to stand	Northern General Hospital
* Stand to sit	Northern General Hospital
* Stand	Northern General Hospital
* Ass walking	Northern General Hospital
* Walking	Northern General Hospital
* Stairs	Northern General Hospital
* Up stairs	Northern General Hospital
* Down stairs	Northern General Hospital
* Transfer ass 1	Northern General Hospital
* Stand ass 1	Northern General Hospital
* Walk with frame and supervision	Northern General Hospital
* Independent sit 5 mins	Northern General Hospital
* Stand ass 1	Northern General Hospital
* Transfer ass 1	Northern General Hospital
* Transfer ass husband	Northern General Hospital
* Transfer ass 1	Northern General Hospital
* Independent sit 5 mins	Northern General Hospital
* Lying to sit	Northern General Hospital
* Sit to stand ass 1	Northern General Hospital
* Stand ass 1	Northern General Hospital
* Independent stand	Northern General Hospital
* Stand to sit	Northern General Hospital
* Independent sit 10 mins	Northern General Hospital
* Stand with min ass	Northern General Hospital
* Ass sit to stand	Northern General Hospital
* Ass stand to sit	Northern General Hospital
* Sit to stand	Northern General Hospital
* Stand to sit	Northern General Hospital
* Drinking with L arm	Northern General Hospital
* Ass transfer bed to chair	Northern General Hospital
* Ass walking	Northern General Hospital
* Stand walk and sit	Northern General Hospital
* Stairs with rail	Northern General Hospital
* Sit to stand	Northern General Hospital
* Stand to sit	Northern General Hospital
* Standing	Northern General Hospital

* Drinking with L hand	Northern General Hospital
* Walking	Northern General Hospital
* Stairs	Northern General Hospital
* Floor to sit	Northern General Hospital
* Rolling	Northern General Hospital
* Sitting	Northern General Hospital
* Transfer ass 1	Northern General Hospital
* Stand ass 2	Northern General Hospital
* Sit to stand independently	Northern General Hospital
* Stand	Northern General Hospital
* Drink using R hand	Northern General Hospital
* Sit to stand without prompt	Northern General Hospital
* Stand	Northern General Hospital
* Walk	Northern General Hospital
* Independent toileting	Northern General Hospital
* Throw ball with R arm	Northern General Hospital
* Independent stand	Northern General Hospital
* Sit to stand min ass	Northern General Hospital
* Stand to sit min ass	Northern General Hospital
* Walk on ward min ass	Northern General Hospital
* Sit to stand min ass	Northern General Hospital
* Stand to sit min ass	Northern General Hospital
* Independent stand	Northern General Hospital
* Walk with min ass	Northern General Hospital
* Independent sitting	Nether Edge Hospital
* Independent standing	Nether Edge Hospital
* Sit to stand	Nether Edge Hospital
* Stepping with L leg	Nether Edge Hospital
* Stepping with R leg	Nether Edge Hospital
* Sitting	Nether Edge Hospital
* Standing balance	Nether Edge Hospital
* Sit to stand	Nether Edge Hospital
* Stepping with R leg	Nether Edge Hospital
* Stepping with L leg	Nether Edge Hospital
* Sit to stand	Nether Edge Hospital
* Step with R leg	Nether Edge Hospital
* Walking	Nether Edge Hospital
* Selective upper limb control	Nether Edge Hospital

* Eliminate positive support	Nether Edge Hospital
* Walk	Nether Edge Hospital
* Selective hand activity	Nether Edge Hospital
* Automatic balance activity	Nether Edge Hospital
* Independent functional sit	Nether Edge Hospital
* Sit to stand	Nether Edge Hospital
* Side to side rolling	Nether Edge Hospital
* Transfer	Nether Edge Hospital
* Normal head alignment	Northern General Hospital
* Placed upright sitting	Northern General Hospital
* Placed midline standing	Northern General Hospital
* Independent sitting	Northern General Hospital
* Sit to stand min ass	Northern General Hospital
* Sit unsupported	Northern General Hospital
* Sit to stand min ass	Northern General Hospital
* Stand min ass	Northern General Hospital
* Stepping with L and R	Northern General Hospital
* Stand to sit	Northern General Hospital
* Roll to R with verbal prompt	Northern General Hospital
* Lying to sitting with verbal prompt	Northern General Hospital
* Sitting	Northern General Hospital
* Sit to stand min ass	Northern General Hospital
* Standing	Northern General Hospital
* Sit to stand	Northern General Hospital
* Independent stand	Northern General Hospital
* Stand to sit	Northern General Hospital
* Sit to stand transfer	Northern General Hospital
* Standing	Lincoln
* Stepping with R leg	Lincoln
* Stepping with L leg	Lincoln
* Associated reactions L arm	Lincoln
* Independent walking	Lincoln
* Sitting balance	Lincoln
* Transfer sit to stand	Lincoln
* Standing balance	Lincoln
* Stepping with R leg	Lincoln
* Walking	Lincoln
* Sit standing with ass 1	Lincoln

* Standing	Lincoln
* Stepping to side with L	Lincoln
* Sitting balance	Lincoln
* Transfer technique	Lincoln
* Motivation/attention	Lincoln
* Standing	Lincoln
* Hip and knee control	Lincoln
* Shoulder	Lincoln
* Treatment tolerance	Lincoln
* Sitting balance	Lincoln
* Sit stand transfer	Lincoln
* Independent standing	Lincoln
* Transfer with carer	Lincoln

All returned TELER forms include to date 5.2.94
Forms to come Worksop, Mansfield.

APPENDIX 2.2

Description of Stroke Patients Involved in First Delphi Round n=41

Age	Location of Stroke	Rankin Score	Number Indicators	Step and Plateau Pattern Traced
66	Left hemisphere	4	6	5
75	Right Partoid lobe	5	6	5
78	NA	5	7	3
77	Left internal capsual	5	5	3
61	Right frontoparietal	4	8	6
79	Right hemisphere	3	5	0
74	Left hemisphere	5	5	5
85	Left TACI	5	3	3
71	Right internal capsual	4	5	1
89	Left PACI	4	3	0
80	Right Lacunar	3	4	0
80	Right hemisphere	5	3	2
83	Left PACI	4	3	3
68	Left TACI	5	4	2
69	Right hemisphere	4	5	0
88	Left hemisphere	5	4	4
71	Right frontoparietal lobe	4	7	7
NA	Left hemisphere	3	6	2
31	Right hemisphere	4	5	5
45	Left hemisphere	4	6	3
59	Left hemisphere	4	6	0
65	Left hemisphere	4	5	3
67	Right hemisphere	4	4	2
80	Right hemisphere	4	3	1
54	Right hemisphere	4	5	5
79	Left hemisphere	4	5	2
35	Right hemisphere	3	5	1
57	Left hemisphere	2	3	0
54	Left hemisphere	5	4	4
74	Left hemisphere	4	4	4
78	Left hemisphere	5	4	4
66	Right hemisphere	5	5	4
71	Right hemisphere	5	5	4
71	Right middle CA	5	3	1
52	Right parietal lobe	4	4	4
47	Right hemisphere	4	6	4
75	Left hemisphere	5	4	4
79	Right parietal lobe	4	4	2
64	Left hemisphere	5	4	4
60	Left hemisphere	4	4	2
66	Right parietal lobe	4	5	4
Total Mean	66		192	118
SD	13.46			

APPENDIX 2.3

Developmental Process to Satisfy Theoretical Basis of Bobath Approach

Sitting Indicator Definitions

TELER Indicator First Delphi Round

Indicator Name: Independent Sitting

- 0: Unable
- 1: Able to take weight symmetrically through buttocks
- 2: Able to take weight symmetrically through feet
- 3: Able to maintain shoulders symmetrically over pelvis
- 4: Able to rest hands equally on knees
- 5: Able to move away from and back to midline



TELER Indicator Second Delphi Round

Indicator Name: Independent Sitting

- 0: Unable
- 1: Able to take weight through buttocks
- 2: Able to take weight through feet
- 3: Able to maintain shoulders symmetrically over pelvis
- 4: Able to rest hands equally on knees
- 5: Able to move away from and back to midline



TELER Indicator Third Round Consensus Meeting

Indicator Name: Maintained Sitting

- 0: Unable to be placed
- 1: Able to take weight through buttocks
- 2: Able to take weight through feet
- 3: Able to maintain shoulders aligned over pelvis
- 4: Able to rest hands equally on knees
- 5: Able to maintain midline sitting

Developmental Process to Satisfy Measurement Theory

Rolling Indicator Definitions

TELER Indicator Second Delphi Round

Indicator Name: Rolling

- 0: Unable
- 1: Able to lift head and turn
- 2: Able to move one arm across midline
- 3: Able to rotate upper trunk to midline
- 4: Able to move one leg across midline
- 5: Able to rotate lower trunk to midline



TELER Indicator Third Round Consensus Meeting

Component Indicator

Indicator Name: Turning Over

- * Flex both legs
 - * Posterior tilt pelvis
 - * Lift and turn lower trunk
 - * Lift and turn head and upper trunk
 - * Move both arms
-
- 0: Unable to achieve any of the components
 - 1: Able to achieve 1 of the components
 - 2: Able to achieve 2 of the components
 - 3: Able to achieve 3 of the components
-
- 4: Able to achieve 4 of the components
 - 5: Able to achieve all of the components

Developmental Process for the TELER Stroke Outcome Indicators

Lying Indicator Definitions

TELER Indicator First Delphi Round

Indicator Name: Lying

- 0: Unable
- 1: Able to lie symmetrically
- 2: Able to move head independently
- 3: Able to rest upper limbs on supporting surface
- 4: Able to rest lower limbs on supporting surface
- 5: Able to move away from and back to lying position



TELER Indicator Second Delphi Round

Indicator Name: Lying (able to accept base of support)

- 0: Unable
- 1: Able to lie symmetrically
- 2: Able to rest upper and lower limbs on supporting surface
- 3: Able to move head independently
- 4: Able to move away from midline
- 5: Able to back to midline



TELER Indicator Third Round Consensus Meeting

Indicator Name: Maintain Lying (Prone, supine, side lying)

- 0: Unable to be placed in lying
- 1: Able to align head on trunk
- 2: Able to align limbs to trunk
- 3: Able to move head
- 4: Able to move an arm
- 5: Able to move a leg

**Protocol and Data Collection Form for 3rd Stage Validation Study of the
Normal Movement TELER Outcome Indicators**

Sue Mawson
Senior Lecturer
Sheffield Hallam University
School of Health and Community Studies

Sample

A convenience sample will be used for this stage, all new patients referred for treatment following a stroke that fulfil the following inclusion and exclusion criteria may be included in the study.

Inclusion Criteria

Any patient who has had a C.V.A. with a neurological deficit lasting longer than 24 hours.

Exclusion Criteria

Dementia.

Severe short term memory loss.

Severe physical disability prior to stroke, i.e. any patient not independently ambulant.

Procedure for New Patient

- Assess patient subjectively to determine what his/her/carers goals for treatment are.
- Assess patient objectively to determine whether goals identified are achievable, renegotiable if required.
- During assessment score patient on the Rankin Handicap Scale and the NIH Stroke Scale (see Appendix 6), (both included).
- Document patients problem list.
- Using catalogue determine which indicators will measure the changes in ability required to achieve the identified goals, i.e. if patients goal is independent washing choose the following:
 - Maintained sitting
 - Sitting
 - Functional arm

The patient may simply want to sit independently or transfer in which case choose the appropriate indicator. Indicators should be chosen to maximally stress the CNS whilst maintaining the clinical standards identified in the catalogue.

- If none of the Indicators fulfil the patients needs design a new indicator.
- Document indicators that will measure the outcome of your intervention.
- Be realistic, i.e. initially use only 3 indicators and add more as these are achieved.
- Document treatment and tick appropriately, date and score indicator.
- The scoring of the Normal Movement Indicators should be incorporated into the treatment process and should represent the highest level achieved during treatment.
- Scores can be taken at other times to fulfil specific requirements, i.e. before treatment to determine whether overflow from previous sessions has occurred, in the Ward situations to determine whether the patient can achieve the movements in different environments, etc.
- Use the visual presentation of change as a dynamic record of treatment effect. If patient plateaus ask the following questions:
 - is the Indicator correct?
 - should treatment be modified?
 - should the environment be modified?
 - should the patient be referred to other disciplines?
 - should treatment be discontinued?
- Document scores at the end of the episode of care for use if patient returns or is re-referred to your department or another service area.

Scoring

To avoid the possibility of therapist bias in scoring the patients ability to achieve any functional skill, a crossover design will be used.

The patient will be scored by an independent scorer during each treatment session using the appropriate TELER Indicators and MAS Motor Tasks, and as dictated by the participating unit on the Barthel Index.

Motor Assessment Scale

Please score appropriate motor tasks that relate to the Normal Movement Indicator identified by the treating physiotherapist. Score at each treatment session.

Barthel Index

Please date and score patient in accordance with practice on your unit, i.e. at the beginning and end of episode of care.

At discharge please send Research data collection forms to Sue Mawson at Sheffield Hallam University.

If any new Indicators have been developed over this 6 month period, please include a copy of these to enable the continuing development of the Normal Movement Catalogue.

APPENDIX 3.2

NORMAL MOVEMENT TELER INDICATORS CLINICAL STANDARDS CRITERIA FOR SCORING

To ensure the quality of the movements measured by the TELER Indicators, all the clinical standards identified below must be achieved by the patients when scoring either motor task indicators or component indicators. These clinical standards are in accordance with the concept of the Normal Movement approach originally developed by the late Dr and Mrs K. Bobath:

- Bilateral weight bearing activities must be symmetrical.
- Bilateral trunk activities must be in alignment.
- Appropriate postural alignment must be achieved.
- Trunk and limb activities must be achieved without the presence of associated reactions.
- Trunk and limb activities must be achieved without the presence of compensatory fixation.
- Movements must be carried out in a smooth, co-ordinated and controlled manner.
- Lateral weight transference should be to the limit of the cone of stability.
- The ability to move a limb must be selectively, purposefully, freely and in the appropriate alignment.

Indicators must be chosen to maximally stress the CNS whilst still maintaining the required clinical response.

APPENDIX 3.3

Motor Assessment Scale Criteria for Scoring

1. Supine to Side Lying onto Intact Side

1. Pulls himself into side lying. (Starting position must be supine lying, not knees flexed. Patient pulls himself into side lying with intact arm, moves affected leg with intact leg).
2. Moves leg across actively and the lower half of the body follows. (Starting position as above. Arm is left behind).
3. Arm is lifted across body with other arm. Leg is moved actively and body follows in a block. (Starting position as above).
4. Moves arm across body actively and the rest of the body follows in a block. (Starting position as above).
5. Moves arm and leg and rolls to side but overbalances. (Starting position as above. Shoulder protracts and arm flexes forward).
6. Rolls to side in 3 seconds. (Starting position as above. Must not use hands).

2. Supine to Sitting over Side of Bed

1. Side lying, lifts head sideways but cannot sit up. (Patient assisted to side lying).
2. Side lying to sitting over side of bed. (Therapist assists patient with movement. Patient controls head position throughout).
3. Side lying to sitting over side of bed. (Therapist gives stand-by help (see Appendix 2) by assisting legs over side of bed).
4. Side lying to sitting over side of bed. (With no stand-by help).
5. Supine to sitting over side of bed. (With no stand-by help).
6. Supine to sitting over side of bed within 10 seconds. (With no stand-by help).

APPENDIX 3.4

GENERAL RULES FOR ADMINISTERING THE M.A.S.

1. The test should preferably be carried out in a quite private room or curtained area.
2. The test should be carried out when patient is maximally alert. For example, not when he is under the influence of hypnotic or sedative drugs. Record should be made if patient is under the influence of these drugs.
3. Patients should be dressed in suitable street clothes with sleeves rolled up and without shoes and socks. Items 1 to 3 inclusively may be scored if necessary with patient in his night clothes.
4. Each item is recorded on a scale of 0 to 6.
5. All items are to be performed independently by the patient unless otherwise stated. "Stand-by help" means that the physical therapist stands by and may steady the patient but must not actively assist.
6. Items 1 to 8 are recorded according to the patient's responses to specific instructions. General Tonus, item 9, is scored from continuous observations and handling throughout the assessment.
7. Patient should be scored on his best performance. Repeat three times unless other specific instructions are stated.
8. Because the scale is designed to score patient's best performance, the physical therapist should give general encouragement but should not give specific feedback on whether response is correct or incorrect. Sensitivity to the patient is necessary to enable him to produce his best performance.
9. Instructions should be repeated and demonstrations given to patient if necessary.
10. The order of administration of items 1 to 9 can be varied according to convenience.
11. If patient becomes emotionally labile at any stage during scoring, the physical therapist should wait 15 seconds before attempting the following procedures:
 - i) ask the patient to close his mouth and take a deep breath
 - ii) hold patient's jaw closed and ask the patient to stop crying.

If patient is unable to control behaviour, the examiner should cease testing him and rescore this item and any other items unscored at a more suitable time.

6. Holding a comb and combing hair at back of head.

9. **General Tonus**

1. Flaccid, limp, no resistance when body parts are handled.

2. Some response felt as body parts are moved.

3. Variable, sometimes flaccid, sometimes good tone, sometimes hypertonic.

4. Consistently normal response.

5. Hypertonic 50% of the time.

6. Hypertonic at all times.

7. Hand Movements

1. Sitting, extension of wrist. (Therapist should have patient sitting at a table with forearm resting on table. Therapist places cylindrical object in palm of patient's hand. Patient is asked to lift object off the table by extending the wrist. Do not allow elbow flexion).
2. Sitting, radial deviation of wrist. (Therapist should place forearm in midpronation-supination, i.e. resting on lunar side, thumb in line with forearm and wrist in extension, fingers around a cylindrical object. Patient is asked to lift hand off table. Do not allow elbow flexion or pronation).
3. Sitting, elbow into side, pronation and supination. (Elbow unsupported and at a right angle. Three-quarter range is acceptable).
4. Reach forward, pick up large ball of 14 cm (5 inches) diameter with both hands and put it down. (Ball should be on table so far in front of patient that he has to extend arms fully to reach it. Shoulders must be protracted, elbows extended, wrist neutral or extended. Palms should be kept in contact with the ball).
5. Pick up a polystyrene cup from table and put it on table across other side of body. (Do not allow alteration in shape of cup).
6. Continuous opposition of thumb and each finger more than 14 times in 10 seconds. (Each finger in turn taps the thumb, starting with index finger. Do not allow thumb to slide from one finger to the other, or to go backwards).

8. Advanced Hand Activities

1. Picking up the top of a pen and putting it down again. (Patient stretches arm forward, picks up pen top, releases it on table close to body).
2. Picking up one jellybean from a cup and placing it in another cup. (Teacup contains eight jellybeans. Both cups must be at arms length. Left hand takes jellybean from cup on right and releases it in cup on left).
3. Drawing horizontal lines to stop at a vertical line 10 times in 20 seconds. (At least five lines must touch and stop at the vertical line).
4. Holding a pencil, making rapid consecutive dots on a sheet of paper. (Patient must do at least 2 dots a second for 5 seconds. Patient picks pencil up and positions it without assistance. Patient must hold pen as for writing. Patient must make a dot not a stroke).
5. Taking a dessert spoon of liquid to the mouth. (Do not allow head to lower towards spoon. Do not allow liquid to spill).

5. Walking

1. Stand on affected leg and steps forward with other leg. (Weight-bearing hip must be extended. Therapist may give stand-by help).
2. Walks with stand-by help from one person.
3. Walks 3m (10 feet) alone or uses any aid but no stand-by help.
4. Walks 10 m (33 feet) with no aid, turns around, picks up a small sandbag from floor and walks back in 25 seconds. (May use either hand).
5. Walks up and down four steps with or without an aid but without holding on to the rail three times in 35 seconds.

6. Upper Arm Function

1. Lying protract shoulder girdle with arm in elevation. (Therapist places arm in position and supports it with elbow in extension).
2. Lying, hold extended arm in elevation for 2 seconds. (Physical therapist should place arm in position and patient must maintain position with some external rotation. Elbow must be held within 20° of full extension).
3. Flexion and extension of elbow to take palm to forehead with arm as in 2. (Therapist may assist supination of forearm).
4. Sitting, hold extended arm in forward flexion at 90° to body for 2 seconds. (Therapist should place arm in position and patient must maintain position with some external rotation and elbow extension. Do not allow excess shoulder elevation).
5. Sitting, patient lifts arm to above position, holds it there for 10 seconds and then lowers it. (Patient must maintain position with some external rotation. Do not allow pronation).
6. Standing, hand against wall. Maintain arm position while turning body towards wall. (Have arm abducted to 90° with palm flat against the wall).

3. Balanced Sitting

1. Sits only with support. (Therapist should assist patient into sitting).
2. Sits unsupported for 10 seconds. (Without holding on, knees and feet together, feet can be supported on floor).
3. Sits unsupported with weight well forward and evenly distributed. (Weight should be well forward at the hips, head and thoracic spine extended, weight evenly distributed on both sides).
4. Sits unsupported, turns head and trunk to look behind. (Feet supported and together on floor. Do not allow legs to abduct or feet to move. Have hands resting on thighs, do not allow hands to move onto plinth).
5. Sits unsupported, reaches forward to touch floor and returns to starting position. (Feet supported on floor. Do not allow patient to hold on. Do not allow legs and feet to move. Support affected arm if necessary. Hand must touch floor at least 10 cm (4 inches) in front of feet).
6. Sits on stool unsupported, reaches sideways to touch floor and returns to starting position. (Feet supported on floor. Do not allow patient to hold on. Do not allow legs and feet to move. Support affected arm if necessary. Patient must reach sideways not forward).

4. Sitting to Standing

1. Gets to standing with help from therapist. (Any method).
2. Gets to standing with stand-by help. (Weight unevenly distributed, uses hands for support).
3. Gets to standing. (Do not allow uneven weight distribution or help from hands).
4. Gets to standing and stands for 5 seconds with hips and knees extended. (Do not allow uneven distribution).
5. Sitting to standing to sitting with no stand-by help. (Do not allow uneven weight distribution. Full extension of hips and knees).
6. Sitting to standing to sitting with no stand-by help three times in 10 seconds. (Do not allow uneven weight distribution).

3.4.1. MOTOR ASSESSMENT SCALE

	Date:						Date:						Date:								
	0	1	2	3	4	5	6	0	1	2	3	4	5	6	0	1	2	3	4	5	6
1. Supine to Side Lying																					
2. Supine to Sitting over Side of Bed																					
3. Balanced Sitting																					
4. Sitting to Standing																					
5. Walking																					
6. Upper-Arm Function																					
7. Hand Movements																					
8. Advanced Hand Activities																					
9. General Tonus																					

1. Supine to Side Lying
2. Supine to Sitting over Side of Bed
3. Balanced Sitting
4. Sitting to Standing
5. Walking
6. Upper-Arm Function
7. Hand Movements
8. Advanced Hand Activities
9. General Tonus

Comments (if applicable):

	Date:						Date:						Date:								
	0	1	2	3	4	5	6	0	1	2	3	4	5	6	0	1	2	3	4	5	6
1. Supine to Side Lying																					
2. Supine to Sitting over Side of Bed																					
3. Balanced Sitting																					
4. Sitting to Standing																					
5. Walking																					
6. Upper-Arm Function																					
7. Hand Movements																					
8. Advanced Hand Activities																					
9. General Tonus																					

1. Supine to Side Lying
2. Supine to Sitting over Side of Bed
3. Balanced Sitting
4. Sitting to Standing
5. Walking
6. Upper-Arm Function
7. Hand Movements
8. Advanced Hand Activities
9. General Tonus

Comments (if applicable):

THE BARTHEL ADL INDEX
(GUIDELINES)

General

The Index should be used as a record of *what a patient does NOT* as a record of *what a patient could do*.

The main aim is to establish *degree of independence from any help*, physical or verbal, however minor and for whatever reason.

The need for *supervision* renders the patient: *NOT independent*.

A patient's performance should be established *using the best available evidence*. Asking the patient, friends/relatives and nurses will be the usual source, but direct observation and common sense are also important. However, *direct testing is not needed*.

Usually the performance over the *preceding 24-48 hours* is important, but occasionally longer periods will be relevant.

Unconscious patients should score '0' throughout, even if not yet incontinent.

Middle categories imply that patient supplies over *50% of the effort*.

Use of aids to be independent is allowed.

Ambulation

3	<i>Independent</i>	May use any aid except rolling walker; speed not important. (Used to be 50 meters, but about house is equivalent).
2	<i>Needs help</i>	Verbal or physical supervision, including help up into Zimmer frame or other help standing.
1	<i>Independent in wheelchair</i>	Must be able to negotiate corners alone.
0	<i>Immobile</i>	Including being wheeled by another.

Stairs

2	<i>Independent</i>	Must carry walking aid if used.
1	<i>Needs help</i>	Physical or verbal supervision, carrying aid etc.
0	<i>Unable</i>	Needs lift (elevator), or cannot negotiate stairs.

Bladder

2	<i>Continent</i>	Able to use any device (eg catheter) if necessary
1	<i>Occasional Accident</i>	Less than once weekly, needs help with device.
0	<i>Incontinent</i>	

Toilet

2	<i>Independent</i>	Able to handle clothes, wipe self, flush toilet, empty commode completely unaided. Able to get on and off alone.
1	<i>Needs help</i>	Able to manage with minor help balancing, handling clothes or toilet paper. However, still able to use toilet.
0	<i>Dependent</i>	Unable to manage without major assistance.

Chair Bed Transfers

3	<i>Independent</i>	No help; includes locking wheelchair if necessary.
2	<i>Minimal help</i>	Includes verbal supervision and minor physical help such as given by not very strong spouse.
1	<i>Major help</i>	Able to sit unaided, but needs much help.
0	<i>Dependent</i>	Needs hoist or complete lift by two people. Unable to sit.

APPENDIX 3.5

BARTHEL ADL SCALE NOTES FOR SCORING

Feeding

2	<i>Independent</i>	Able to use any necessary device; feeds in a reasonable time; able to cut up food, use condiments, spread butter etc on his own. Food may be placed within reach.
1	<i>Needs help</i>	eg with cutting, or spreading butter.
0	<i>Dependent</i>	Needs to be fed.

Bathing

1	<i>Independent</i>	Able to wash self all over; may be by using shower, a full bath or standing and sponging all over. Includes getting into and out of bath, or shower room.
0	<i>Dependent</i>	Needs some help.

Grooming

1	<i>Independent</i>	Doing all personal activities, eg washing hands and face, combing hair. Includes shaving and teeth. Not to need any help.
0	<i>Dependent</i>	Needs some help.

Bowels

2	<i>Continent</i>	If needs enema, suppository, must manage it himself.
1	<i>Occasional Accident</i>	Rare (under once a week); needs help with enema.
0	<i>Incontinent</i>	

12. If performance is scored differently on left and right side, the physical therapist may indicate this with an 'L' in one box and 'R' in another box.
13. The patient should be informed when he is being timed.
14. You will need the following equipment:

- a low wide plinth
- a stopwatch
- a polystyrene cup
- eight jellybeans
- two teacups
- a rubber ball approximately 14 cm (5 inches) diameter
- a stool
- a comb
- a top off a pen
- a table
- a dessert spoon and water
- a pen
- a prepared sheet for drawing lines
- and a cylindrical object such as a jar.

BARTHEL ADL INDEX

	0	1	2	3	Admission	Discharge
1. Mobility	immobile	wheelchair independent	supervised	independent +/- aid		
2. Transfers	unable	major help	minor help	independent		
3. Stairs	unable	with help	independent			
4. Toilet Use	dependent	needs some help	independent			
5. Bladder	incontinent or use catheter	some problems	continent			
6. Bowels	incontinent or regular enema	occasional problem	continent			
7. Bathing	dependent	independent				
8. Grooming	needs help	independent				
9. Dressing	dependent	some help	independent			
10. Feeding	dependent	some help	independent			
20 Independent	15 - 19 Mildly Dependent	10 - 14 Moderately Dependent	5 - 9 Severely Dependent	0 - 4 Very severely Dependent	TOTAL	

APPENDIX 3.8

Characteristics of Patients Involved with Phase III

Location	Age	Gender	Site	Rankin Score	NIH Scores	N Goals	N with Plats	Barthel Adm	Barthel Disc
NE 1	61	F	RCVA	4	0/0/0/0/1/1/1/0	7	7	11	11
NE 2	NA	M	RCVA	4	0/0/0/0/3/2/0/0	8	8	NA	NA
NE 3	75	F	LCVA	4	0/0/0/0/1/3/0/0	8	7	11	19
NE 4	59	F	LCVA	5	0/0/1/0/0/0/0/0	9	7	NA	NA
CRT TM1	74	M	RCVA	2	0/2/1/0/3/0/1/0	5	4	NA	NA
CRT TM2	NA	M	RCVA	4	0/2/1/2/3/3/0/0	3	3	8	11
CRT TM3	72	M	RCVA	3	0/1/0/0/3/2/0/0	3	3	11	18
RH 1	68	F	LCVA	4	0/0/0/0/0/0/0/0	5	1	15	18
RH 2	46	M	LCVA	3	0/1/0/0/3/2/0/0	4	4	16	20
RH 3	55	M	RCVA	5	2/2/0/0/3/3/0/0	5	5	6	18
NTGH 1	52	M	RCVA	3	0/1/1/1/2/1/1/0	6	5	4	17
NTGH 2	43	M	LCVA	3	0/1/1/0/2/0/0/0	5	4	10	20
HGH 1	75	M	RCVA	AD 3 DIC 3	0/1/0/0/0/0/1/0	4	2	0	2
HDG 2	75	M	LCVA	AD 5 DIC 4	3/0/0/0/3/3/1/0	3	3	13	18
HDG 3	74	M	RCVA	AD 3 DIS 2	0/1/0/0/0/1/0/0	4	4	10	18
MDG 1	NA	M	RCVA	AD 5 DIC 4	0/1/0/0/3/2/0/0	9	9	0	6
MDG 2	55	M	LCVA	5	3/2/2/0/3/3/0/0	5	5	5	8
THR 1	71	F	LCVA	AD 4 DIS 3	1/1/1/0/3/3/1/0	3	1	5	11
THR 2	65	M	LCVA	AD 4 DIS 3	1/1/1/0/3/3/1/0	3	3	7	10
THR 3	NA	NA	NA	AD 4 DIS 1	0/1/2/1/1/3/3/0	7	3	1	20
NTGH 3	44	M	LCVA	3	0/1/0/0/2/1/0/0	3	3	15	19
HDG 5	NA	M	LCVA	4	0/0/1/0/3/2/1/0	7	7	9	13
HM 1	51	F	RCVA	5	2/1/2/1/3/3/1/0	5	4	2	Died
HM 2	58	M	RCVA	4	1/1/0/0/3/2/1/0	8	2	3	17

HM 3	48	M	RCVA	5	0/0/0/0/3/1/0/0	7	5	9	20
HM 4	42	M	LCVA	4	1/1/0/0/3/1/0/0	8	6	8	20
MDG 3	64	M	LCVA	4	NA	4	4	NA	NA
ML 1	58	M	LCVA	3	0/0/0/0/0/1/0/0	5	5	18	18
ML 2	NA	M	LCVA	4	0/0/0/0/3/2/0/0	7	5	7	9
Mean	60								
Total						160	129		

APPENDIX 3.9.1

Chi-square analysis used to test for associations in Chapter 10.

3.9.1.1. Chi-square Analysis to establish whether an association existed between the initial handicap and the Site of the Lesion

iv) Expected Number of Involved Hemispheres

Score	L	R
2	0.99	1.01
3	5.91	6.09
4	15.77	16.23
5	11.33	11.67

v) Calculated chi-square

Score	L	R	Total
2	0.0001	0.0001	0.0002
3	0.0014	0.0013	0.0027
4	0.0376	0.0365	0.0741
5	0.0396	0.0385	0.0781
Total	0.0787	0.0764	0.1551

3.9.1.2. Chi-square Analysis to establish whether there was an association between the site of the CVA and the Neglect Score on the NIH stroke scale

iv) Expected Number of hemispheres involved

Neglect Score on NIH	L	R
0	16.26	17.74
1	13.87	15.13
2	2.87	3.13

v) Calculated chi-square

Score	L	R	Total
0	0.033	0.031	0.064
1	0.092	0.084	0.176
2	1.218	1.117	2.335
Total	1.343	1.232	2.575

3.9.1.3. Chi-square Analysis To establish whether there was an association between the hemisphere involved and the scores on the TELER Indicators of Maintain Sit and Dynamic Sit

iv) Expected number of hemispheres involved

TELER scores	L	R
0	6.81	6.2
1	5.76	5.24
2	8.91	8.1
3	0.524	0.48

v) Calculated chi-square

Score	L	R	Total
0	1.16	1.265	2.425
1	0.267	0.3	0.567
2	0.133	0.173	0.306
3	0.226	0.48	0.706
Total	1.786	2.218	4.004

3.9.1.4. Analysis of Denes et al., (1982) data using standard Chi-square Test

iv) Expected Number of hemispheres involved

Copying Crosses Test	L	R
No Unilateral Spatial Neglect	17.5	17.5
Unilateral Spatial Neglect	6.5	6.5

v) Calculated chi-square

Copying Crosses Test	L	R	Total
No Unilateral Spatial Neglect	0.129	0.129	0.259
Unilateral Spatial Neglect	0.346	0.346	0.692
Total	10.475	0.475	0.95

3.9.1.5. Analysis of Data using Chi-square formula with percentage Data.

iv) Expected Percentage of hemispheres involved

Copying Crosses Test	L	R	Total
No Unilateral Spatial Neglect	25%	25%	48(100%)
Unilateral Spatial Neglect	25%	25%	48(100%)
Total			100%

v) Calculated chi-square

Copying Crosses Test	L	R	Total
No Unilateral Spatial Neglect	9	2.56	11.56
Unilateral Spatial Neglect	5.625	1.94	7.57
Total	14.625	4.5	19.125

3.9.1.6 Analysis of Recovery Pattern for Subject A (RH2) using Chi-square Test

iv) Expected numbers

TELER Scores	I	NC	D
Post WE	4.12	13.5	1.31
Post PT	13.88	45.5	4.62

v) Calculated chi-square

Scores	1	NC	0	Total
Post WE	0.0035	1.225	9.618	10.847
Post PT	0.00104	0.2692	2.8364	3.107
Total	0.00454	1.4942	12.4544	13.933

3.9.1.7. Analysis of Recovery Pattern for Subject B (HDG2) using Chi-square Test

iv) Expected numbers

TELER Scores	I	NC	D
Post WE	5.81	29.66	1.53
Post PT	13.2	67.34	3.47

v) Calculated chi-square

Scores	I	NC	0	Total
Post WE	0.113	0.239	7.87	10.847
Post PT	0.049	0.105	3.47	3.107
Total	0.162	0.344	11.34	11.846

3.9.1.8. Chi-square Analysis of 10 subjects to establish whether weekend Fallbacks occurred in the Recovery of Dynamic Standing scored on the TELER Indicator of Dynamic Stand

iv) Expected numbers

TELER Scores	I	NC	D
Post WE	8.49	36.86	2.65
Post PT	23.16	102.14	7.35

v) Calculated chi-square

Scores	I	NC	0	Total
Post WE	0.73	0.094	7.141	7.97
Post PT	0.348	0.034	2.57	2.952
Total	1.078	0.128	9.711	10.917

3.9.1.9. Chi-square Analysis of 8 subjects to establish whether weekend Fallbacks occurred in the Recovery of Dynamic Sit scored on the TELER Indicator of Dynamic Sit

iv) Expected number

TELER Scores	I	NC	D
Post WE	6.89	24.63	2.46
Post PT	21.1	75.36	7.54

v) Calculated chi-square

Scores	I	NC	D	Total
Post WE	0.518	0.28	8.37	9.168
Post PT	0.171	0.092	2.72	2.983
Total	0.681	0.372	11.09	12.143

3.9.1.10. Chi-square Analysis of 6 subjects to establish whether weekend Fallbacks occurred in the Recovery of Maintained Sit scored on the TELER Indicator of Maintained Sit

iv) Expected numbers

TELER Scores	I	NC	D
Post WE	7.79	23.38	1.81
Post PT	22.2	66.61	5.18

v) Calculated chi-square

Scores	I	NC	0	Total
Post WE	0.0057	0.242	2.65	2.8977
Post PT	0.0018	0.085	0.918	1.005
Total	0.0075	0.327	3.568	3.903

3.9.1.11. Chi-square Analysis of 6 subjects to establish whether weekend Fallbacks occurred in the Recovery of Maintained Stand scored on the TELER Indicator of Maintained Stand

iv) Expected numbers

TELER Scores	I	NC	D
Post WE	4.89	16.88	1.223
Post PT	15.1	52.1	3.72

v) Calculated chi-square

Scores	I	NC	0	Total
Post WE	0.002	0.209	2.571	2.782
Post PT	0.0006	0.069	0.784	0.8536
Total	0.0026	0.278	3.355	3.636

3.9.1.12. Chi-square Analysis to establish whether there was an Association between scores achieved on the indicator of Maintained Sit with a large base of support and Maintained Stand with a small base of support.

iv) Expected numbers

Maintained Stand	Maintained Sit					
	0	1	2	3	4	5
0	1.478	1.033	3.1	3.44	3.62	23.42
1	0.459	0.344	1.033	1.148	1.206	7.809
2	0.383	0.287	0.861	0.957	1.005	6.507
3	0.842	0.632	1.895	2.105	2.211	14.32
4	0.536	0.402	1.206	1.34	1.407	9.11
5	4.402	3.401	2.904	11.005	11.555	74.831

v) Calculated chi-square

Maintained Stand	Maintained Sit						Totals
	0	1	2	3	4	5	
0	4.3	8.302	15.36	0.091	0.039	7.689	35,781
1	27.31	7.846	15.207	0.019	1.206	7.809	59.39,
2	0.38	0.287	1.494	4.354	3.96	3.121	13,596
3	0.842	0.632	0.411	16.49	43.33	12.49	74,195
4	0.536	0.402	1.206	1.34	0.249	0.917	4,474
5	4.402	3.401	2.904	4.46	11.555	17.48	44,202
Totals	37.77	20.48	36.65	26.75	60.334	49.5	231.48

3.9.1.13. Chi-square Analysis to establish whether there was an Association between scores achieved on the indicator of Dynamic Sit with a large base of support and Dynamic Stand with a small base of support.

iv) Expected numbers

Dynamic Stand	Dynamic Sit					
	0	1	2	3	4	5
0	0.735	0.735	3.235	4.853	9.853	15.588
1	0.525	0.525	2.311	3.466	7.038	11.13
2	0.378	0.378	1.664	2.495	5.07	8.017
3	1.176	1.176	5.176	7.764	15.76	24.94
4	1.303	1.303	5.73	8.6	17.45	27.61
5	0.882	0.882	3.882	5.824	11.823	18.7

v) Calculated chi square

Dynamic Stand	Dynamic Sit						Totals
	0	1	2	3	4	5	
0	24.75	14.53	18.65	0.0045	0.826	10.16	68.96
1	0.525	0.525	19.36	5.931	0.131	11.13	37.6
2	0.378	1.024	0.068	2.515	3.046	6.144	13.175
3	1.176	1.176	5.176	2.311	5.417	1.414	16.67
4	1.303	1.303	5.73	3.646	0.017	6.494	18.493
5	0.882	0.882	3.882	8.6	17.45	29.03	60.726
Totals	29.01	19.44	52.86	23.001	26.89	64.37	215.571

3.9.1.14. Chi-square Analysis to establish whether there was an Association between scores achieved on the indicator of Maintained Stand and Dynamic Stand both being achieved on the same base of support.

iv) Expected numbers

Dynamic Stand	Maintained Stand					
	0	1	2	3	4	5
0	3.308	1.654	2.389	4.778	3.308	27.75
1	1.846	0.92	1.33	2.667	1.846	15.49
2	1.154	0.58	0.83	1.66	1.154	9.68
3	3.15	1.58	2.28	4.556	3.15	26.46
4	7.154	3.577	5.167	10.33	7.154	60
5	1.385	0.69	1	2	1.385	11.62

v) Calculated chi-square

Dynamic Stand	Maintained Stand						Totals
	0	1	2	3	4	5	
0	65.25	52.31	18.29	0.01	0.52	27.75	164
1	1.846	0.92	5.4	32.65	0.72	5.8	47.3
2	1.154	0.58	0.83	0.262	20.35	0.29	23.5
3	3.15	1.58	2.27	17.22	0.23	3.44	27.89
4	7.154	3.577	5.145	21.42	2.4	8.82	48.5
5	1.385	0.69	0.996	1	2	3.5	9.6
Totals	80	60	33	72.6	26.22	49.6	321

3.9.1.15. Chi-square Analysis to establish whether there was an Association between scores achieved on the indicator of Maintained Sit and Dynamic Sit both being achieved on the same base of support.

iv) Expected numbers

Dynamic Sit	Maintained Sit					
	0	1	2	3	4	5
0	0.053	0.048	0.101	0.213	0.059	0.527
1	0.798	0.718	1.516	3.191	0.878	7.899
2	1.011	0.91	1.92	4.043	1.112	10.005
3	0.957	0.862	1.819	3.83	1.053	9.48
4	3.25	2.92	6.165	12.98	3.57	32.12
5	13.94	3.543	7.48	15.75	4.33	38.971

v) Calculated chi-square

Dynamic Sit	Maintained Sit						Totals
	0	1	2	3	4	5	
0	11.56	0.048	0.101	0.213	0.059	0.529	12.942
1	33.91	2.29	13.263	3.191	0.878	6.026	59.558
2	0.0001	10.5	13.44	0.27	0.0112	4.91	29.13
3	0.002	1.502	0.37	1.23	0.852	1.28	5.236
4	1.56	1.263	2.81	3.8	5.5	0.303	15.236
5	3.94	3.543	2.68	1.433	4.33	11.35	27.276
Totals	50.97	19.146	32.66	10.14	11.63	24.398	148.944

APPENDIX 3.9.2

Results of Chi-square analysis for 5 randomly selected patients

Patient RH3

Observed Numbers

Score	I	NC	D	Total
Post WE	4	1	4	9
Post PT	19	41	4	64
Total	23	42	8	73

Patient RH3

Expected Numbers

Score	I	NC	D	Total
Post WE	2.836	5.178	0.986	
Post PT	20.16	36.82	7.014	
Total				

Patient RH3

Calculated Chi-square

Score	I	NC	D	Total
Post WE	0.478	3.371	8.1	11.95
Post PT	0.067	0.474	1.295	1.836
Total	0.545	3.845	10.5	14.89

Patient NE1

Observed Numbers

Score	I	NC	D	Total
Post WE	5	11	8	24
Post PT	19	48	5	72
Total	24	59	13	96

Patient NE1

Expected Numbers

Score	I	NC	D	Total
Post WE	6	14.75	3.25	
Post PT	18	44.25	9.75	
Total				

Patient NE1

Calculated Chi-square

Score	I	NC	D	Total
Post WE	0.167	0.953	6.942	8.062
Post PT	0.056	0.318	2.314	2.688
Total	0.222	1.271	9.256	10.75

Patient MDG3

Observed Numbers

Score	I	NC	D	Total
Post WE	0	2	10	10
Post PT	10	30	0	40
Total	10	32	10	52

Patient MDG3

Expected Numbers

Score	I	NC	D	Total
Post WE	2.308	7.385	2.308	
Post PT	7.692	24.62	7.692	
Total				

Patient MDG3

Calculated Chi-square

Score	I	NC	D	Total
Post WE	2.308	3.926	25.64	31.874
Post PT	0.692	1.178	7.692	9.562
Total	3	5.104	33.33	41.44

Patient NE2

Observed Numbers

Score	I	NC	D	Total
Post WE	2	12	5	19
Post PT	12	33	0	45
Total	14	45	5	64

Patient NE2

Expected Numbers

Score	I	NC	D	Total
Post WE	4.156	13.36	1.484	

Post PT	9.844	31.64	3.516	
Total				

Patient NE2

Calculated Chi-square

Score	I	NC	D	Total
Post WE	1.119	0.138	8.326	9.583
Post PT	0.472	0.058	3.516	4.046
Total	1.591	0.197	11.84	13.63

Patient NE3

Observed Numbers

Score	I	NC	D	Total
Post WE	2	7	3	12
Post PT	8	18	0	26
Total	10	25	3	38

Patient NE3

Expected Numbers

Score	I	NC	D	Total
Post WE	3.158	7.895	0.947	
Post PT	6.842	17.11	2.053	
Total				

Patient NE3

Calculated Chi-square

Score	I	NC	D	Total
Post WE	0.425	0.101	4.447	4.973
Post PT	0.196	0.047	2.053	2.296
Total	0.621	0.148	6.5	7.269

APPENDIX 3.9.3.

Rank Correlations used to assess the validity of certain TELER and MAS scores.

Subject NTG 1 TELER Maintained Sit and MAS Balanced Sit

d	d ²			
0	0			
0	0	r	=	1 - $\frac{6 \times \Sigma d^2}{n(n^2 - 1)}$
1	1			
1	1			
1	1	r	=	1 - $\frac{6 \times 6}{10(10^2 - 1)}$
0	0			
1	1			
1	1	r	=	1 - $\frac{36}{990}$
1	1			
0	0			
		r	=	1 - 0.03636
$\Sigma d^2 = 6$				
n = 10		r	=	0.9636
		r ²	=	93%

Having documented the method of analysis used, the following results will only include a summary of the results to include, the number of scores, the total of the squares of the differences between the scores, the rank correlation and the strength of the agreement between the scores.

Subject MLI TELER Dynamic Sitting MAS Balanced Sitting

$\Sigma d^2 = 82$	r = 0.96
n = 23	r ² = 92%

Rank correlations of TELER scores correlated with MAS walk item individually and as groups of Indicators.

Subject RH3 TELER Maintained Stand and MAS Walking

$\Sigma d^2 = 154$	$r = 0.93$
$n = 24$	$r^2 = 87\%$

Subject RH3 TELER Dynamic Stand and MAS Walking

$\Sigma d^2 = 77$	$r = 0.966$
$n = 24$	$r^2 = 93\%$

Subject RH3 TELER Stand to Step and MAS Walking

$\Sigma d^2 = 28$	$r = 0.987$
$n = 24$	$r^2 = 98\%$

Subject RH3 TELER Maintained Stand, Dynamic Stand, Stand to Step R and MAS Walking

$\Sigma d^2 = 259$	$r = 0.9958$
$n = 71$	$r^2 = 99.16\%$

APPENDIX 3.9.3. 1.

Chi- square analysis to establish whether the TELER Indicator of Sit to Stand was more responsive to change in motor skill ability than the MAS.

iv) Expected numbers

	I	NC	D
TELER	19.79	32.98	4.239
MAS	22.21	37.02	4.76

v) Calculated chi-square

	I	NC	0	Total
TELER	0.9	1.475	1.8	4.175
MAS	0.8	1.314	1.601	3.715
Total	1.698	2.79	3.398	7.890

APPENDIX 3.9.4.

Chi-square analysis to establish whether between treatment 'fallbacks' occurred the the recovery of a series of TELER Indicators for 1 subject A NE5 and for 4 subjects including A NE5.

3.9.4.1.To establish whether between treatment 'fallbacks' occurred in the recovery of Maintained Sit during 11 treatment sessions for subject A NE5 the scores on the TELER indicator of Maintained Sit were analysed as follows:

iv) Expected numbers

	I	NC	D
Pre-treatment → Treatment	4.695	4.174	3.13
Treatment → Pre-treatment	4.3	3.83	2.86

v) Calculated chi-square

	I	NC	D	Total
Pre-treatment → Treatment	3.95	0.33	3.13	7.41
Treatment → Pre-treatment	4.3	0.36	3.45	8.11
Total	8.25	0.69	6.58	15.5

3.9.4.2. To establish whether between treatment 'fallbacks' occurred in the recovery of Dynamic Sit during 27 treatment sessions for subject A NE5 the scores on the TELER indicator of Dynamic Sit were analysed as follows:

iv) Expected numbers

	I	NC	D
Pre-treatment → Treatment	8.5	11.5	7
Treatment → Pre-treatment	8.5	11.5	7

v) Calculated chi-square

	I	NC	D	Total
Pre-treatment → Treatment	4.97	0.02	5.14	10.13
Treatment → Pre-treatment	4.9	0.02	5.14	10.13
Total	9.87	0.04	10.28	20.26

3.9.4.3. To establish whether between treatment 'fallbacks' occurred in the recovery of Maintained Stand during 29 treatment sessions for subject ANE5 the scores on the TELER indicator of Maintained Stand were analysed as follows:

iv) Expected numbers

	I	NC	D
Pre-treatment → Treatment	8.9	12.3	7.7
Treatment → pre- treatment	9.2	12.7	8.14

v) Calculated chi-square

	I	NC	O	Total
Pre-treatment → Treatment	9.31	0.43	5.83	15.57
Treatment → pre-treatment	9.3	0.42	5.78	15.5
Total	19.27	0.685	14.02	31.07

3.9.4.4. To establish whether between treatment 'fallbacks' occurred in the recovery of Dynamic Standing during 32 treatment sessions for subject ANE5 the scores on the TELER indicator of Dynamic Stand were analysed as follows:

iv) Expected numbers

	I	NC	D
Pre-treatment → Treatment	8.157	11.216	6.63
Treatment → pre-treatment	7.543	10.78	6.37

v) Calculated chi-square

	I	NC	D	Total
Pre-treatment → Treatment	5.738	0.00415	6.63	12.37
Treatment → pre-treatment	5.675	0.0045	6.9	12.57
Total	11.413	0.0086	13.53	24.95

3.9.4.5. To establish whether between treatment 'fallbacks' occurred in the recovery of Dynamic Sit for 4 subjects including ANE5 the scores on the TELER indicator of Dynamic Sit were analysed as follows:

iv) Expected numbers

	I	NC	D
Pre-treatment → Treatment	25.3	16.008	21.68
Treatment → pre-treatment	23.69	14.99	20.31

v) Calculated chi-square

	I	NC	D	Total
Pre-treatment → Treatment	18.6	0.0635	19.72	38.38
Treatment → pre-treatment	119.85	0.068	21.07	40.98
Total	138.45	0.13	40.8	79.38

Appendix 3.10

Rank Correlation Coefficients r and Strength of Agreement r^2

Subject	TELER	MAS	r	r^2	Sit e
NE2	Mtd Sit	Bal Sit	0.9643	93%	R
	Dy Sit	Bal Sit	0.8928	80%	
	Dy Sit/Mtd Sit	Bal Sit	0.98	96%	
	Sit Std	Sit Std	0.7322	54%	
	Mtd A/BalA/Supp A	Upp A	0.9786	96%	
NE4	Mtd Sit	Bal Sit	0.9684	94%	L
	Dy Std	Walk	0.7203	52%	
	Step L/Step R	Walk	0.9835	97%	
CRT TM2	Dy Sit	Bal Sit	0.8	64%	R
HDG3	Sit Std	Sit Std	0.905	82%	R
	Dy Sit	Bal Sit	0.7143	51%	
HGH2	Dy Std	Walk	0.9	81%	R
	Func Hd	Hd Movts	0.7	49%	
NTGH2	Sit Std	Sit Std	0.958	92%	L
	Func Walk	Walk	0.818	67%	
	Supp A	Upp A	0.96	92%	
	Manip A	Upp A	0.96	92%	
HDG1	Dy Sit	Bal Sit	0.954	91%	L
	Mtd Sit	Bal Sit	0.986	97%	
	Supp A	Upp A	0.9895	98%	
NE1	Mtd Sit	Bal Sit	0.9835	97%	R
	Dy Sit	Bal Sit	0.9534	91%	
	Mtdst/Dy st/Dy Std	Sit Std	0.9964	99%	
CRT TM1	Func Walk	Walk	0.514	26%	R
ML2	Mtd Sit/Dy Sit	Bal Sit	0.8111	66%	L
ML1	Dy Sit	Bal Sit	0.96	92%	L
	Step L/Step R	Walk	0.9955	99%	
MDG2	Mtd Sit	Bal Sit	0.7555	57%	R
THR4	Mtd Sit	Bal Sit	0.8857	79%	R
	Dy Sit	Bal Sit	0.743	55%	
	Mtd Sit/Dy Sit	Bal Sit	0.954	91%	

Subject	TELER	MAS	r	r ²	Sit e
NE5	Mtd Sit	Bal Sit	0.99	98%	R
	Dy Sit	Bal Sit	0.9825	97%	
	Sit Std	Sit Std	0.996	99%	
	Func Walk	Walk	0.9824	97%	
NE3	Sit Std	Sit Std	0.943	89%	L
	Step L/Step R	Walk	0.825	68%	
	Func Walk	Walk	0.8	64%	
HM5	Dy Sit	Bal Sit	0.661	44%	L
	Sit Std	Sit Std	0.679	46%	
	Mtd A	Upp A	0.911	83%	
THR2	Mtd Sit	Bal Sit	0.939	88%	L
	Dy Sit	Bal Sit	0.9816	96%	
	Mtd Sit/Dy Sit	Bal Sit	0.99	98%	
THR1	Mtd Sit	Bal Sit	0.903	82%	L
	Dy Sit	Bal Sit	0.9878	98%	
	Mtd Sit/Dy Sit	Bal Sit	0.986	97%	
CRT TM3	Trans	Bal Sit	0.914	84%	R
	Step L/Step R	Walk	0.63	40%	
HM1	Dy Sit	Bal Sit	0.357	13%	R
	Sit Std	Sit Std	0.9286	86%	
	Mtd A	Upp A	0.946	90%	
RH3	Sit Std	Sit Std	0.9944	99%	L
	Mtd Sit	Bal Sit	0.9896	98%	
	Mtd Std/Dy Std/Step R	Walk	0.9958	87%	
	Mtd Std	Walk	0.93	93%	
	Dy Std	Walk	0.966	98%	
	Step R	Walk	0.987	99.16 %	
NTGH1	Mtd Sit	Bal Sit	0.9636	93%	R
	Sit Std	Sit Std	0.782	61%	
	Mtd A	Upp A	0.8458	85%	
RH1	Sit Std	Sit Std	0.95	90%	L
	Step R	Walk	0.9	81%	
	Step L	Walk	0.8464	72%	
	Func Walk	Walk	0.53	28%	
	Ststd/Stp L/Stp R	Walk	0.947	90%	

Subject	TELER	MAS	r	r ²	Site
RH2	Mtd Sit	Bal Sit	0.946	90%	L
	Sit Std	Sit Std	0.89	79%	
	Step L	Walk	0.97	94%	
	Step R	Walk	0.848	72%	
MDG1	Mtd Sit	Bal Sit	0.824	68%	L
	Dy Sit	Bal Sit	0.9576	92%	
	Mtd St/Dy St	Bal Sit	0.973	95%	
HM4	Sit Std	Sit Std	0.9533	91%	L
	Mtd A	Upp A	0.9396	88%	
HM3	Dy Sit	Bal Sit	0.903	82%	R
HM2	Mtd A	Upp A	0.875	77%	R
	Dy Std	Walk	0.679	46%	

Appendix 3.11

Rank Correlation for Specific Indicators

Subject	TELER	MAS	Rank Correlation	Agreement
Sitting				
NE2	Mtd Sit	Bal Sit	0.9643	93
NE2	Dy Sit	Bal Sit	0.8928	80
NE2	Dy Sit/Mtd Sit	Bal Sit	0.98	96
NE4	Mtd Sit	Bal Sit	0.9684	94
CRT TM2	Dy Sit	Bal Sit	0.8	64
HDG3	Dy Sit	Bal Sit	0.7143	51
HDG1	Dy Sit	Bal Sit	0.954	91
HDG1	Mtd Sit	Bal Sit	0.986	97
NE1	Mtd Sit	Bal Sit	0.9835	97
NE1	Dy Sit	Bal Sit	0.9534	91
ML2	Mtd Sit/Dy Sit	Bal Sit	0.8111	66
ML1	Dy Sit	Bal Sit	0.96	92
MDG2	Mtd Sit	Bal Sit	0.7555	57
THR4	Mtd Sit	Bal Sit	0.8857	79
THR4	Dy Sit	Bal Sit	0.743	55
THR4	Mtd Sit/Dy Sit	Bal Sit	0.954	91
NE5	Mtd Sit	Bal Sit	0.99	98
NE5	Dy Sit	Bal Sit	0.9825	97
HM5	Dy Sit	Bal Sit	0.661	44
THR2	Mtd Sit	Bal Sit	0.939	88
THR2	Dy Sit	Bal Sit	0.9816	96
THR2	Mtd/Dy Sit	Bal Sit	0.99	98
THR1	Mtd Sit	Bal Sit	0.903	82
THR1	Dy Sit	Bal Sit	0.9878	98
THR1	Mtd Sit/Dy Sit	Bal Sit	0.986	97
HM1	Dy Sit	Bal Sit	0.357	13
RH3	Mtd Sit	Bal Sit	0.9896	98
NTGH1	Mtd Sit	Bal Sit	0.9636	93
RH2	Mtd Sit	Bal Sit	0.946	90
MDG1	Mtd Sit	Bal Sit	0.824	68
MDG1	Dy Sit	Bal Sit	0.9576	92
MDG1	Mtd St/Dy St	Bal Sit	0.973	95
HM3	Dy Sit	Bal Sit	0.903	82
Sit to Stand				
NE2	Sit Std	Sit Std	0.7322	54
HDG3	Sit Std	Sit Std	0.905	82
NTGH2	Sit Std	Sit Std	0.958	92
NE1	MtdSt/Dyst/Dy Std	Sit Std	0.9964	99
NE5	Sit Std	Sit Std	0.996	99
NE3	Sit Std	Sit Std	0.943	89
HM5	Sit Std	Sit Std	0.679	46

HM1	Sit Std	Sit Std	0.9286	86
RH3	Sit Std	Sit Std	0.9944	99
NTGH1	Sit Std	Sit Std	0.782	61
RH1	Sit Std	Sit Std	0.95	90
RH2	Sit Std	Sit Std	0.89	79
HM3	Sit Std	Sit Std	0.9533	91

Walking				
NE4	Dy Std	Walk	0.7203	52
NE4	Step L/Step R	Walk	0.9835	97
HDG2	Dy Std	Walk	0.9	81
NTGH2	Func Walk	Walk	0.818	67
CRT TM1	Func Walk	Walk	0.514	26
ML1	Step L/Step R	Walk	0.9955	99
NE5	Func Walk	Walk	0.9824	97
NE3	Step L/Step R	Walk	0.825	68
NE3	Func Walk	Walk	0.8	64
RH3	Mtdstd/Dystd/ StpR	Walk	0.9958	87
CRT TM3	Step L/Step R	Walk	0.63	40
RH3	Mtd Std	Walk	0.93	93
RH3	Dy Std	Walk	0.966	98
RH3	Step R	Walk	0.987	99.16
RH1	Step R	Walk	0.9	81
RH1	Step L	Walk	0.8464	72
RH1	Func Walk	Walk	0.53	28
RH1	Ststd/StpL/Stp R	Walk	0.947	90
RH2	Step L	Walk	0.97	94
RH2	Step R	Walk	0.848	72
RH2	Step L/Step R	Walk		
HM2	Dy Std	Walk	0.679	46
Upper Limb				
NE2	MtdA/BalA/Su pp A	Upp A	0.9786	96
HDH2	Func Hd	Hd Movts	0.7	49
NTGH2	Supp A	Upp A	0.96	92
NTGH2	Manip A	Upp A	0.96	92
HDG1	Supp A	Upp A	0.9895	98
HM5	Mtd A	Upp A	0.911	83
HM1	Mtd A	Upp A	0.946	90
NTGH1	Mtd A	Upp A	0.8485	85
HM4	Mtd A	Upp A	0.9396	88
HM2	Mtd A	Upp A	0.875	77

APPENDIX 4.1

CHI SQUARE ANALYSIS OF 4 TELER INDICATORS SCORED DURING THE TREATMENT OF SUBJECT NE5 IN PHASE IV

SUBJECT A NE5 Treatment - Pre-Treatment Scores

Data was analysed separately to establish whether the pattern observed was significant as independent patterns, ie

Treatment → Pre-Treatment scores

Pre-Treatment → Treatment scores

Maintained Stand

	I	NC	D	Total
Treatment → Pre-Treatment	0	15	15	30
Expected	5	5	5	15
Calculated x^2	5	20	20	45

$$x^2 = 45$$

Dynamic Sit

	I	NC	D	Total
Treatment → Pre-Treatment	2	12	13	27
Expected	9	9	9	27
Calculated x^2	5.4	1	1.78	8.18

$$x^2 = 8.18$$

Maintained Sit

	I	NC	D	Total
Treatment →	0	5	6	11
Pre-Treatment				
Expected	3.6	3.6	3.6	11
Calculated χ^2	3.6	0.54	1.6	5.74

$\chi^2 = 5.74$

Dynamic Stand

	I	NC	D	Total
Treatment →	1	11	13	25
Pre-Treatment				
Expected	8.3	8.3	8.3	25
Calculated χ^2	6.42	0.878	2.66	9.958

$\chi^2 = 9.958$

SUBJECT A NE5 Pre-treatment - Treatment Scores

Dynamic Sit

	I	NC	D	Total
Pre-Treatment → Treatment	15	11	1	27
Expected	9	9	9	27
Calculated x^2	4	0.44	7.1	11.54

$x^2 = 11.54$

Dynamic Stand

	I	NC	D	Total
Pre-Treatment → Treatment	15	11	0	26
Expected	8.6	8.6	8.6	26
Calculated x^2	4.8	0.67	8.6	14.37

$x^2 = 14.37$

Maintained Sit

	I	NC	D	Total
Pre-Treatment → Treatment	9	3	0	12
Expected	4	4	4	12
Calculated x^2	6.25	0.25	4	10.5

$x^2 = 10.5$

Maintained Stand

	I	NC	D	Total
Pre-Treatment → Treatment	18	10	0	28
Expected	9.3	9.3	9.3	28
Calculated χ^2	8.13	0.0527	9.3	17.44

$\chi^2 = 17.44$

The development of selective trunk activity in the child

*Adapted from Illingworth 1987
& Miller et al 1992*

Prone Development

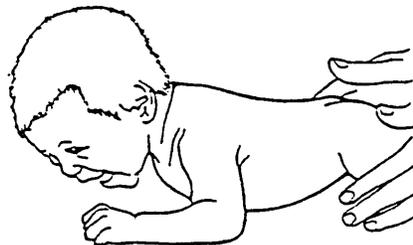
g. A

- 3 weeks.
Physiological flexion of the newborn



g. B

4-6 weeks.
Head and trunk extension with anterior pelvic tilt



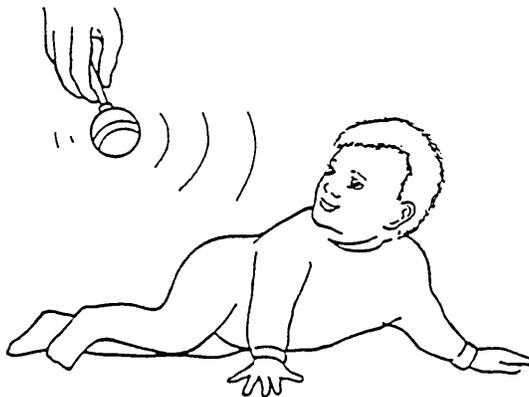
g. C

- 14 weeks.
Head and trunk extension, upper limb weight bearing, lateral weight shift with trunk side flexion



g. D

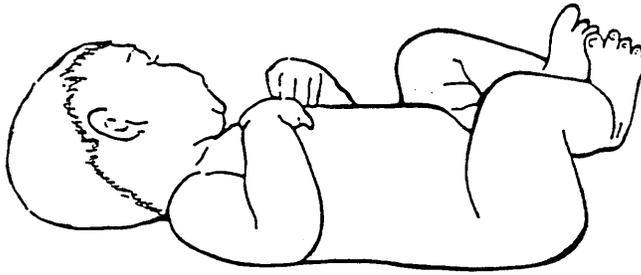
- 32 weeks.
Weight shift with rotation



Flexion Development

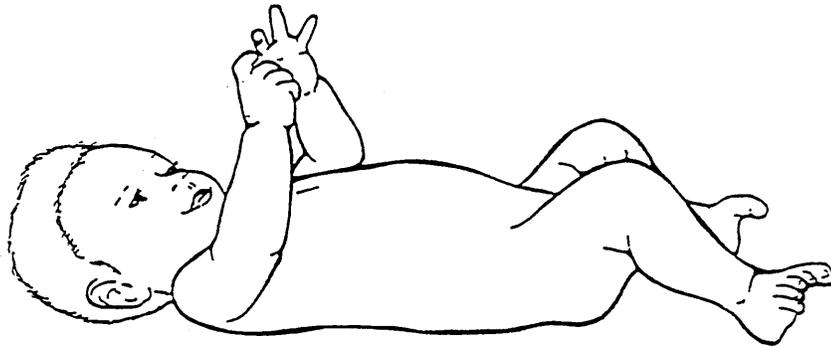
ig. F

2 - 16 weeks.
lays with feet in flexion with
osterior pelvic tilt



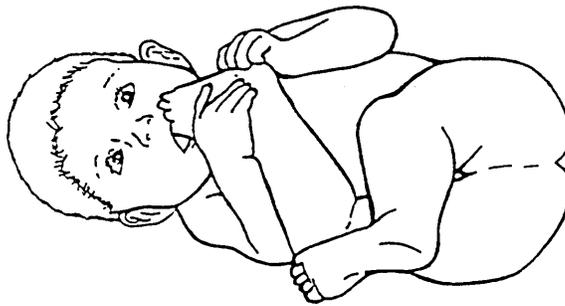
ig. E

0 - 20 weeks.
flexion extension control
trunk and pelvis



ig. H

0 weeks.
flexion, weight shift and rotation



Sitting Development

ig. I

weeks.
flexion of trunk with posterior pelvic tilt in sitting, lacks extension



ig. J

6 weeks.
trunk extension developing in sitting with anterior pelvic tilt



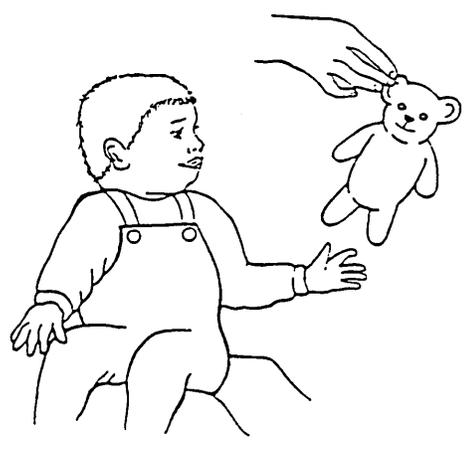
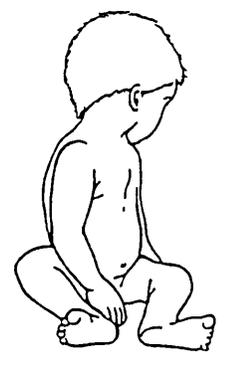
ig. K

6 weeks.
sitting with hand support in extension, lateral weight shift with trunk side flexion



ig. L

1 months.
trunk rotation in sitting



Standing and walking development

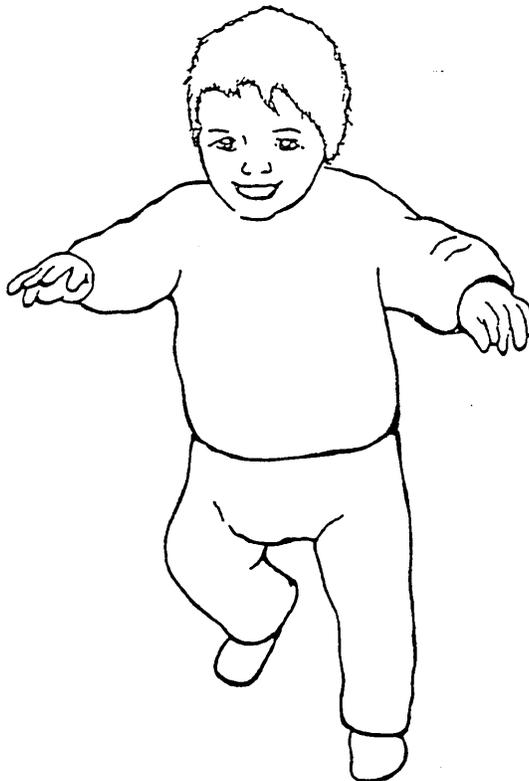
Fig. M

8 weeks.
standing holding on to furniture,
'cruises' and 'cruises' sideways,
using trunk and pelvic extension
and side flexion



Fig. N

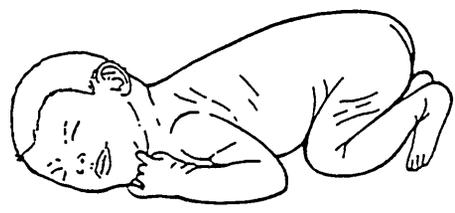
12 months.
walks independently, using wide
base of support, high guard no trunk
rotation



Prone Development

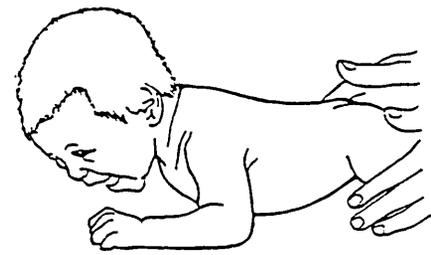
ig. A

- 3 weeks.
hysiological flexion of the
ewborn



ig. B

weeks.
ead and trunk extension with
nterior pelvic tilt



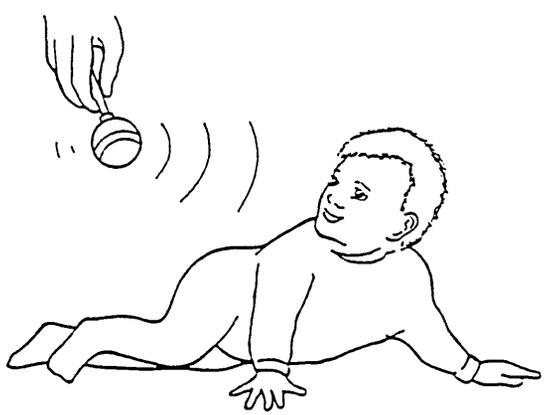
ig. C

2 - 14 weeks.
ead and trunk extension,
pper limb weight bearing
teral weight shift with trunk side
exion



g. D

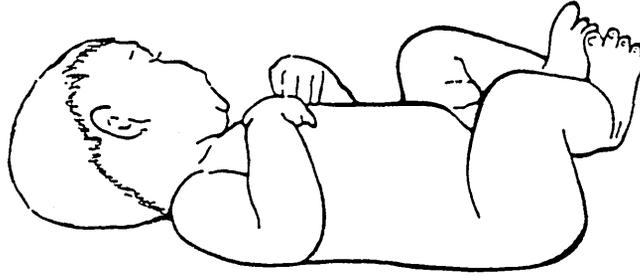
- 32 weeks.
ift with rotation



Flexion Development

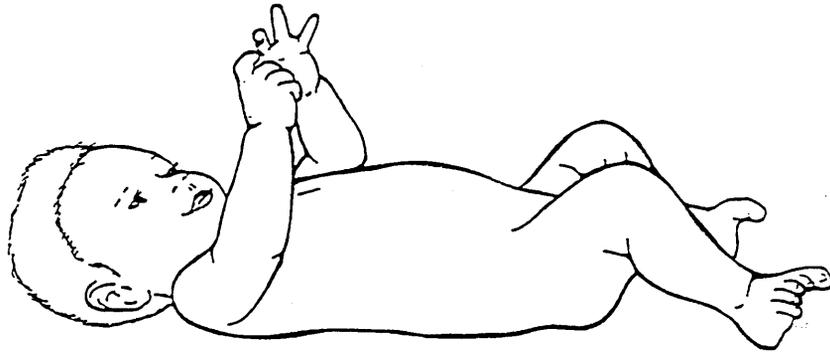
ig. F

2 - 16 weeks.
lays with feet in flexion with
osterior pelvic tilt



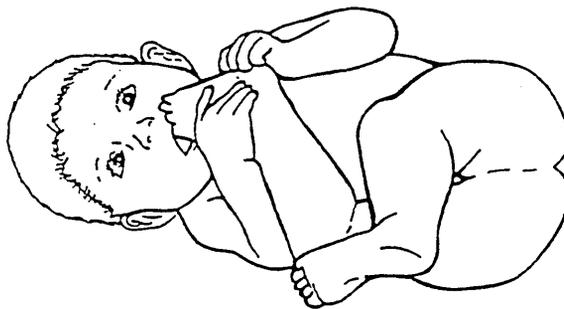
ig. E

0 - 20 weeks.
flexion extension control
trunk and pelvis



g. H

weeks.
exion, weight shift and rotation



Sitting Development

ig. I

weeks.
exion of trunk with posterior
elvic tilt in sitting, lacks
xtension



ig. J

6 weeks.
runk extension developing in
itting with anterior pelvic tilt



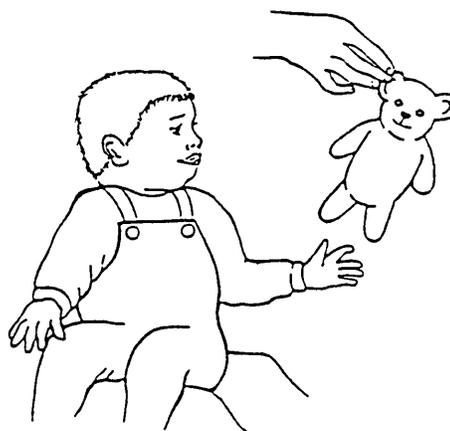
ig. K

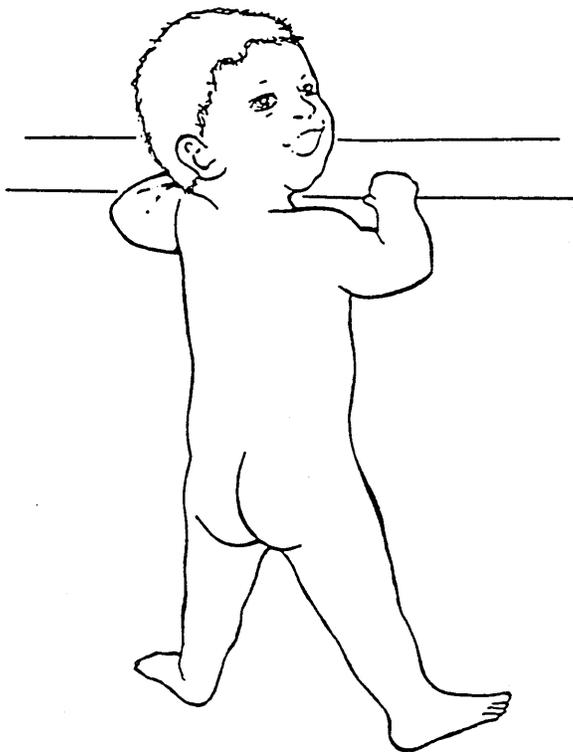
6 weeks.
itting with hand support in
tension, lateral weight shift with
unk side flexion



g. L

1 months.
runk rotation in sitting

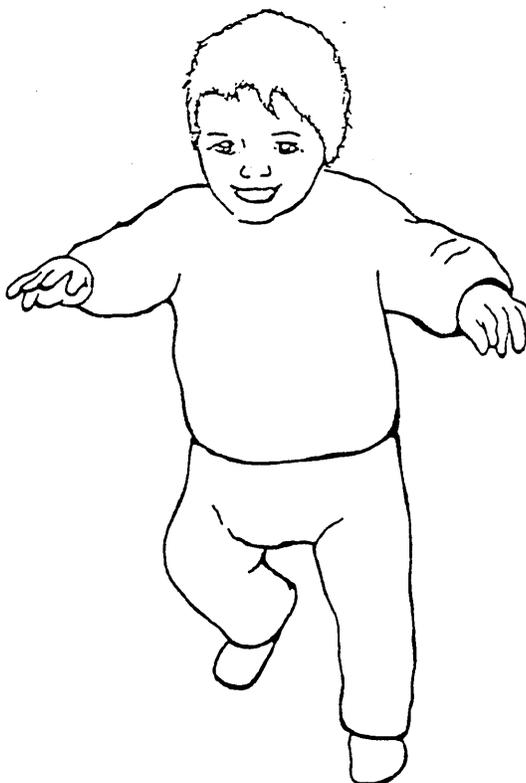




ig. M

8 weeks.

standing holding on to furniture,
'bounces' and 'cruises' sideways,
single trunk and pelvic extension
and side flexion



ig. N

3 months.

Walks independently, using wide
base of support, high guard no trunk
rotation

APPENDIX 6.1

Publications and Presentations by Author

- Mawson S, (1993a) Measuring Physiotherapy Outcome in Stroke Rehabilitation. *Physiotherapy*, 79(11): 762-765. (Peer reviewed)
- Mawson SJ and McCreadie M (1993b) TELER: The Way Forward in Stroke Outcome Audit. Abstract WCPT June, Copenhagen. (Lecture by co-author International)
- Mawson SJ and McCreadie M (1993) TELER: The Way Forward in Clinical Audit. *Physiotherapy*, 79(11): 758-761. (Peer Reviewed)
- Mawson SJ (1994) Measuring the Achievement of Patient Negotiated Goals in Stroke Rehabilitation. Synapse, ACPIN Newsletter, April 39-43.
- Mawson SJ (1994) The Normal Movement Concept: Physiotherapy Outcome Indicators for use with the TELER System. Poster presentation, WCPT 5-7 June. (Poster)
- Mawson SJ (1994b) TELER the Form that Counts, ACPIN Nation Study Day, Outcomes in Neurological Rehabilitation, Manchester. (Lecture)
- Mawson SJ (1994c) TELER Measuring Outcome in Stroke Rehabilitation, Centenary CSP Special Interest Group Conference, Birmingham. (Lecture)
- Mawson SJ (1995) What is the SF-36 and can it measure the outcome of Physiotherapy, 81(12): 208-212. (Peer reviewed)
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- Mawson SJ (1995b) TELER, CSP Study Days on Measuring Outcome in Physiotherapy, March, October. (Lecture)
- Mawson SJ (1995c) The TELER System for Multidisciplinary Outcome Measurement in Neurology, Occupation Therapy Special Interest Group in Neurology (OT SIGN) 21st Jan, Preston. (Key Note Lecture)
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Mawson SJ (1996) The TELER: A purchasers perspective, Scottish Board of the Chartered Society of Physiotherapist Conference 'Purchasing Services and Outcome Measures in Physiotherapy', Sterling University, 25 April. (Lecture)

Mawson SJ (1996) Multidisciplinary Outcomes for the Younger Disabled Client. Oral presentation, National Younger Disabled Unit Conference, Wakefield, 22 May. (Lecture)

Mawson SJ (1996) TELER vs MAS a Validation Study. Oral presentation WCPT-E Eastbourne, 13 September. (Lecture)

Mawson SJ (1996) Measuring the Outcome of Stoke Rehabilitation: A validation study. *Physiotherapy*, 82(8): 466-467. (Abstract)

Mawson SJ (1997) Measuring the Outcome of Physiotherapy in Neurological Rehabilitation. International Congress of the South African Society of Physiotherapy, University of Cape Town. (Lecture)

Mawson SJ (1997) TELER: The way forward in stroke outcome measurement. (Poster)

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growth and development' — paper read at conference on 'Neuroplasticity and the neurologically impaired patient'.

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SCHOLARLY PAPER

TELERTM The Way Forward in Clinical Audit

Susan J Mawson

Michele J McCreddie

Key Words

Audit, framework, input linked to outcome, data analysis, data presentation.

Summary

This paper examines the flexibility of treatment evaluation by A le Roux's method (TELER) and its application in clinical audit. The development of clinical audit in health care is outlined and the audit cycle is explained with a simple example of the cycle in action. Existing audit tools are discussed with respect to Donabedian's framework of the structure, process and outcome of health care. Teler is presented as a system which is compatible with Donabedian's framework which allows clinicians and managers to obtain information required for audit. The characteristics of Teler are illustrated with examples of how data can be gathered, analysed and presented.

Introduction

The Government White Paper 'Working for Patients' (DoH, 1989a) proposed that all doctors should be actively involved in formal audit of their work. More recently, the requirement for audit has been extended to all health care professionals and is termed 'clinical audit'.

By definition, audit requires review, commonly comparison with a set standard. The term 'medical audit' refers to the work of doctors, whereas clinical audit refers to the work of all health care professionals, who may or may not include doctors.

The Department of Health (1989b) defined audit as 'the systematic critical analysis of the quality of [medical] care, including the procedures used for diagnosis and treatment, the use of resources and the resulting outcome and quality of life for the patient'.

More recently, 'audit/quality assurance' has been defined as 'monitoring of current practice and set standards, preferably employing criteria derived from research findings on best practice as well as professional,

management judgements and consumer preferences' (DoH, 1993). Consequently, 'clinical audit' is used as a generic term in this document. Its aims have been defined (JCEM, 1992) as:

- To identify ways of improving and maintaining the quality of care for patients.
- To assist in the training and education of health care professionals.
- To make the most of resources available for health services.

They can be achieved via the audit cycle (fig 1).

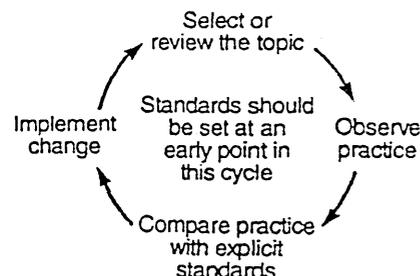


Fig 1: Audit cycle

Stages of the Audit Cycle

Selection of Topic

Various frameworks have been used to identify and structure topics for audit. For example, Maxwell (1984) proposed that they should be considered under the following headings.

- Access
- Relevance
- Effectiveness
- Equity
- Acceptability
- Efficiency and economy

Twenty-five years ago, Donabedian (1966) described a framework where health care is considered in terms of structure, process and outcome.

Structure is concerned with the amount and type of resources asking where the service is provided, with what facilities and by whom.

Process relates to the amount and type of health care activities, asking what is done and how it is done. Process is normally more relevant to health care professionals than structure and may be the most appropriate area for audit.

Outcome describes what has been done, how appropriate it was and what the effect was. Donabedian (1966) defined it as 'the change in the patient's current or future health that can be attributed to medical intervention or other type of antecedent care'.

Observe Practice

The second stage of the audit cycle is observation of current practice. Information can be gathered using audit tools, and falls into the categories described by the Donabedian framework (see table 1).

Table 1: Existing audit tools

Structure
King's Fund organisational audit
British Standards Institution – accreditation to BS5750
Process
Criterion based audit
Diverse occurrence screening
Critical incident reviews
Core note analysis
Questionnaires
Outcome
Patient satisfaction surveys
Peer review
Disease specific measures, eg Arthritis Impact Scale
Topic specific measures, eg Barthel Index
Multi-dimensional health profiles, eg Nottingham Health Profile

Comparison

The essence of audit is the comparison of current practice with an agreed standard. Standards should be set at an early point in the audit cycle. Following this comparison it may be necessary to move on to the fourth stage of the audit cycle.

Implement Change

Appropriate and agreed changes in practice are implemented to 'close the gap' between the observed current practice and the agreed standards.

Re-audit

In order to 'close the loop' of the audit cycle it is important to re-audit the topic using the same standards to ascertain whether the change implemented actually resulted in improving the quality of patient care.

An example of a simple process audit is shown in figure 2.

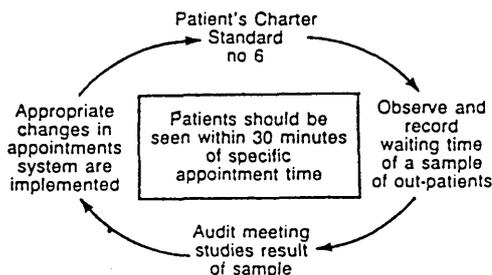


Fig 2: A simple process audit

Audit Tools

The existing audit tools listed in the table contribute valuable information independently. However, combining them to determine the relationship between health status and management, therapeutic process and outcome achieved, is not feasible in clinical practice (Mawson, 1993). The present inability to correlate appropriate data is further compounded by a failure in existing systems to identify variables which could affect the eventual outcome of any intervention.

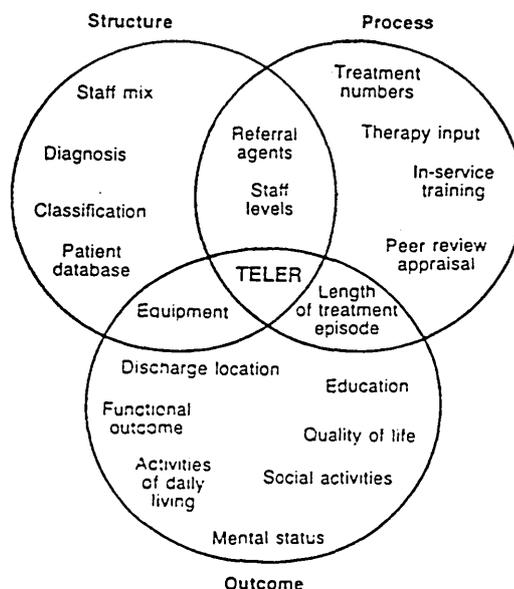
As the essence of audit is comparison with an agreed standard, ideally, all variables should be identified when a standard is set. However, in a dynamic situation such as clinical treatment, some variables may be identified during the process of treatment.

Obvious variables that exist in therapeutic practice include the severity of initial impairment and emotional or psychosocial well being. These must be identified, together with the ability of the system to record emerging variables such as 'staff mix', ward in-service training, and therapeutic interaction. Change should not be implemented as a result of an outcome audit until all the appropriate variables have been identified.

If an effective and efficient audit of outcome is to be made, any method claiming to measure the outcome of physiotherapy must include a wide variety of information. An audit tool that accounts for all variables within the structure and process that may have resulted in or influenced the outcome achieved would be of particular value to all health care professionals.

TELER: The Missing Link

TELER (treatment evaluation by A le Roux's method) (le Roux, 1993) is an ongoing evaluation system that enables both clinicians and managers to obtain information pertinent to the structure, process and outcome of their service, thereby potentially highlighting all variables that may exist (fig 3).



All topics should be reviewed or re-audited at appropriate intervals.

Fig 3: Information provided by TELER.

It can be modified and adapted to provide a variety of management and client-based information. The system at present being piloted in the stroke unit at the Northern General Hospital, Sheffield, has an integral classification system of impairment and handicap (WHO, 1980).

Inclusion of a standardised scale of impairment (Wade, 1992) will provide valuable information regarding the severity of specific areas of impairment such as visual, language and perceptual deficits (Brott *et al.* 1989). This will allow identification and analysis of relationships that may exist between treatment input, achieved outcome and initial severity.

Teler may also be able to provide some of the answers to questions therapists have had inadequate data to answer previously. For example, what effect does profound neglect or global aphasia have on the ultimate outcome of therapeutic input?

Presentation of Data

Teler indicators (table 2) are a visual display of progress towards the achievement of collaborative, functional and attainable goals (le Roux, 1993). Although scored daily by clinicians, audit points may be chosen to provide required information. For example, goal scores (ie outcome indicators) may be recorded at the end of each week of treatment and presented in a graphical form, showing the relationship between treatment, input and outcome (see fig 4). Alternatively, goal scores may be recorded at the beginning of each week to determine the relationship between periods without treatment, such as weekends, and the outcome (fig 5).

As previously discussed, identification of clinical variables should be an essential element in any outcome audit. Figure 6 is a graphical representation of functional goal achievement in a stroke patient with a receptive and expressive aphasia. The fluctuating progress with repeated 'fallbacks' in achievement can be seen quite clearly and could be used by clinicians in both peer audit and future research.

● Goal 1 ■ Goal 3 ▲ Goal 5
 □ Goal 2 △ Goal 4 A - Admission Score

Key to figures 4, 5 and 6

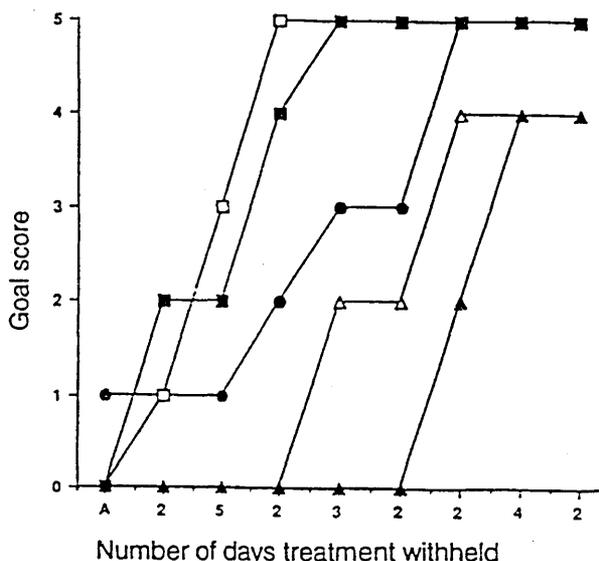


Fig 4: Physiotherapy outcome audit: scores recorded at the beginning of each week

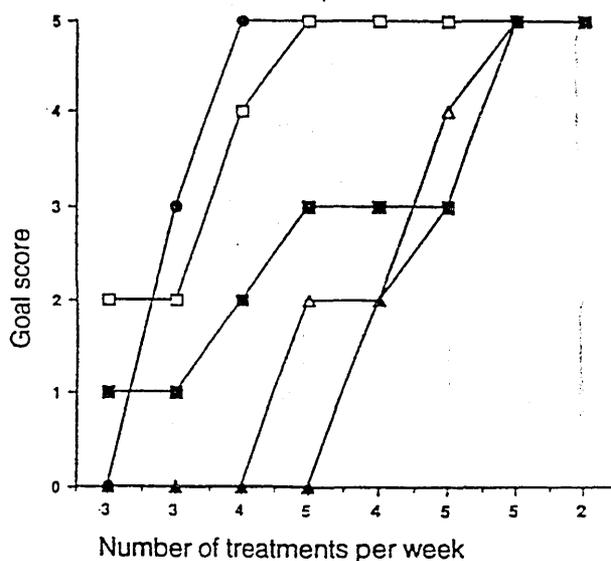
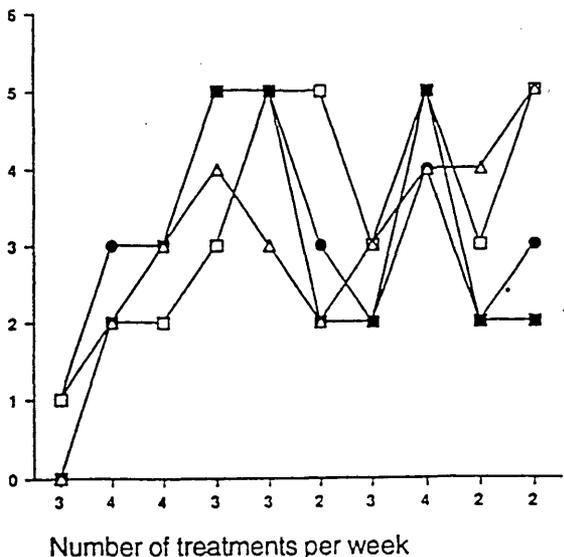


Fig 5: Physiotherapy outcome audit: scores recorded at the end of each week

Table 2: Visual display of progress

Performance indicators	Dates	Date accomplished											
		8/4	9/4	10/4	13/4	14/4	15/4	21/4	22/4	23/4	24/4	27/4	28/4
Sit to stand with one assistant	8/4	0	0	2	2	2	2	2	3	4	4	5	
Assisted stanc	8/4	1	1	1	1	1	1	1	1	2	2	2	
Roll to (R) with assistance	8/4	0	0	0	1	2	3	3	3	4	5	5	
Sit to stand	28/4											2	
Stand to sit with one assistant	7.5												

Number of codes	Frequency of scores											
	0	1	2	3	4	5	0	1	2	3	4	5
0	2	2	1									
1	1	1	1	2	1	1	1	1	1	1		
2			1	1	2	1	1	1	1		1	2
3						1	1	1				
4									1	1	1	
5										1	1	2



Physiotherapy outcome audit: Pattern of recovery of an acute patient

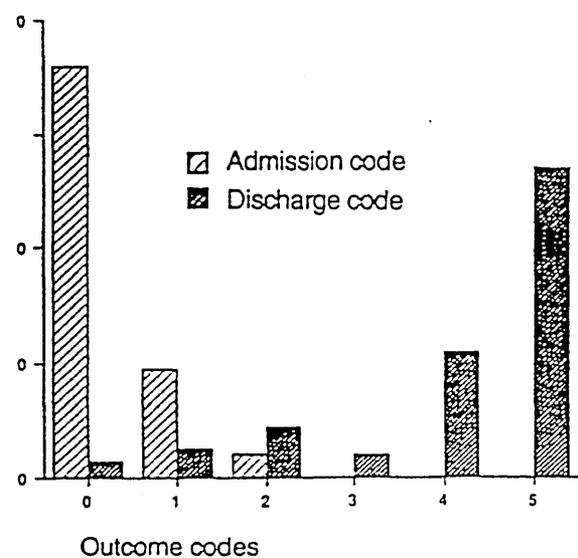
Information provided by the system can be used in many ways to evaluate and analyse clinical practice. For example, TELER will be piloted as a multidisciplinary tool in a regional Disablement Services Centre.

Health economists define data that describe change in health status as a result of intervention as 'hard' data. However, they can be converted into 'hard' data by providing constituent items gathered over time for specific groups of patients.

Data may also be collected for special purposes:

• To compare episodes of care, allowing comparison of outcome input where input is specifically defined in care protocols.

• To identify admission/discharge codes can be identified for groups of patients (fig 7), allowing comparison of outcome achieved in different service areas, eg stroke units and medical wards.



Comparison of admission and discharge codes (n = 18)

• Adverse incident screening may be incorporated to monitor events such as post-operative dislocation of the hip, deep vein thrombosis and chest infections. These incidents may be related to previously defined care protocols.

• Inappropriate referrals can be identified by low achievement codes, leading to establishment of referral criteria and, therefore, reduction of waiting lists. (However, it should be noted that low achievement codes may be the result of a number of other factors, eg initial level of impairment, staff mix, psychosocial elements or environmental issues.)

Conclusion

To achieve an efficient and effective outcome audit, information is required on the structure that provides a care programme, the process of that programme, and variables which occur during the episode of care being evaluated.

TELER provides this within one documentation system and clearly displays that information, in a form easily understood by both clinicians and managers.

Using Teler enables clinicians and managers to improve the quality of patient care, following the observation and analysis of clinical practice.

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Measuring Physiotherapy Outcome in Stroke Rehabilitation

Susan J Mawson

Key Words

Clinical audit, outcome, goal attainment, scale, measurement.

Summary

This paper outlines the process of identifying a suitable system for use in a project to evaluate the characteristics of effective physiotherapy in the rehabilitation of patients following acute cerebral infarction.

Based on a review of existing standardised measures that were deemed reliable and valid and an assessment of need, the researcher describes specifications for a measure of physiotherapy outcome and discusses the value of both standardised measures and the goal attainment approach used in the TELER system. The potential value of TELER as a facilitator of clinical audit is discussed and an outline of the proposed research to be implemented at the Northern General Hospital, Sheffield, to assess the feasibility of using the system and to validate normal movement indicators, is presented.

Introduction

Recent changes within the Health Service have resulted in an increasing need for physiotherapists to quantify the outcome of their therapeutic interventions. Only by developing a system for measuring outcome can the profession undertake a purposeful and valuable clinical audit that will promote and develop quality standards of patient care.

In a recent document *The Health of a Nation* (DoH, 1990) the Government highlighted the need to develop effective measures of outcome from health care. As many clinicians expected, the document specifically identified the rehabilitation services for an evaluation.

Since the publication of the NHS Management Inquiry (Griffiths, 1983), and the implementation of resource management, physiotherapy managers, clinicians and researchers have endeavoured to quantify outcome and provide the hard data essential to back any case for resources in a now competitive market place (DoH, 1990).

The need for information about health gains from physiotherapy was reinforced by Tallis (1989) who quoted evidence submitted to the King's Fund Consensus Forum on Stroke Management: 'Rehabilitation varies widely, mainly reflecting differences in resources but also reflecting different beliefs. There is no absolute proof that individuals or collective services benefit patients. Should rehabilitation be abandoned?'

Although an overstatement of the case, it demonstrates the need to identify measurable outcomes and reinforces the importance of research in clinical practice.

An evaluation of the characteristics of effective physiotherapy intervention in the rehabilitation of patients following acute cerebral infarction was planned at the Northern General Hospital (NGH), Sheffield. Following Wade's advice (1988) that improving existing outcome measures is preferable to doing the equivalent of reinventing the wheel, a preliminary study was designed to achieve the following aims:

- Identify the criteria required for a measure of outcome from physiotherapy.
- Review existing reliable and valid measures and determine whether they fulfil the defined needs.
- Draw up specifications for an evaluation system.
- Identify a system that fulfilled the specification.

Method

An extensive literature search of Medline and Cinahl was undertaken using the online CD-ROM facility at the NGH to identify medical, paramedical and nursing literature.

In order to identify the criteria of need for a measure of outcome in physiotherapy a small qualitative study was undertaken using in-depth semi-structured interviews and observational fieldwork (Quinn Patton, 1987). Information was gathered from managers, physiotherapy clinicians and nursing colleagues. Existing documentation was examined and the physiotherapy process and its integration within the stroke unit was observed.

Analysis

Transcripts of interviews were analysed using the concept book approach (Brenner *et al.*, 1985) in which, following 'immersion within the data', idea elements and categories emerged for interpretation and synthesis.

Findings

During the literature search a number of well documented reliable and valid measures of functional and activities of daily living (ADL) status were identified, including the Barthel Index (Mahoney and Barthel, 1965), the Rivermead Assessment (Lincoln and Leadbetter, 1979), and the Frenchay Assessment (Holbrook and Skilbeck, 1987).

However, as rehabilitation is multidimensional by nature (Fries, 1982), any measure of outcome cannot simply be limited to physical domains. Other measures of anxiety, mental, psychological and occupational status should be included, not only because they affect the outcome of physiotherapy but also because changes within these states are frequently thought to be the result of physiotherapy input.

Table 1: Measuring health status: Existing reliable and valid outcome measures available for evaluating physiotherapy intervention in stroke rehabilitation

Outcome measure	Scored dimensions	Reference
Barthel functional index	Functional status. ADL self care	Mahoney and Barthel (1965)
Overmead motor assessment (RMA)	Functional status. Quality of movement	Lincoln and Leadbetter (1979)
Overmead perceptual assessment (RPA)	Impairment in perceptual modalities	Bhavani <i>et al</i> (1983)
Motoricity index (MI)	Motor impairment	Demeurisse <i>et al</i> (1980)
Nottingham Health profile	Health status and quality of life	Hunt <i>et al</i> (1980)
Penchay activities index	Social activities	Holbrook and Skilbeck (1987)
Abbreviated mental test (AMT)	Mental state	Qureshi and Hodkinson (1974)
Patient satisfaction scale	Health care satisfaction	Daly and Flynn (1985)
Activities index (AI)	ADL and mental capacity	Hamrin and Wohlin (1982)
TELER	Health status. Outcome indicators	Le Roux (1993)

Table 1 lists some of the measures available to health care professionals identified in this study. It also includes the TELER method (Le Roux, 1993) a system not previously documented but used in a number of health authorities in the Trent Region.

During content analysis of the qualitative data, criteria need for a measure of outcome began to emerge. The needs, identified by the health care professionals, were subsequently synthesised into a list of specifications to be fulfilled by a measure (table 2).

Table 2: Specifications to be fulfilled by a measuring system

Feasibility	The system or instrument should allow rapid and easy administration.
Flexibility	The system should allow for a choice and definition of items specific to individual patients' needs, allowing for the definition and measurement of patient-oriented goals.
Precision	The system should be precise enough to allow for clinically significant changes in the patient's health status to be recorded.
Reliability	The system should provide statistically significant data, the outcome being the result of intervention and not spontaneous recovery.
Validatable	The system should include the measurement of change in health status, and the documentation of therapeutic intervention, its timing and frequency.
Multi-disciplinary	The system should have the potential for incorporating a multi-disciplinary audit.

The measures identified in table 1 were compared with the specifications in table 2 and a measure was chosen for use in the proposed project.

Discussion

Comparing the standardised measures with the specifications, it became apparent that they were deficient in a number of areas – feasibility, precision, auditability and focus. Only the TELER system appeared to fulfil all the specifications.

Standardised measures cover many aspects of patient care, basic self care skills, functional independence, social activities, mental and psychological status and perceptual skills. Some were designed specifically for institutional care, others for community care, and the scales of measurement and their weightings vary accordingly (Murdock, 1992).

Rehabilitation outcomes are however multifarious, and to truly reflect the effects of physiotherapy, combinations of measures would be required. The TELER system can incorporate any aspect of outcome covering all the domains previously defined and therefore achieves a level of *feasibility* not achieved by combining standardised measures.

Many clinicians have commented on the lack of sensitivity of standardised measures such as the Barthel Index (Murdock, 1992) to record clinically significant changes in health status, particularly when apparently measuring functional or motor tasks. Eakin (1989) as cited by Murdock (1992) defined a floor effect when using the Barthel Index, stating that a patient scoring 0 may be bed-bound but alert, or could be unconscious. Clinical significance is an integral and essential component of the TELER outcome indicator (Le Roux, 1993) enabling the achievement of *precision* as defined in the specifications.

A number of the measures listed in table 1 are recommended for use as outcome audit tools (Nuffield Institute of Health, 1993). However these 'stand alone' measures are deficient as facilitators of clinical audit because they do not provide information that promotes *auditability*, i.e. that allows correlation of the relationship between changes in health status, treatment input, timing, frequency and staff mix. The TELER system can be modified to provide a variety of management and research information, some of which is listed in table 3.

Table 3: The TELER system

Management information
Referral agent
Discharge location
Patient information
Database
Staff mix
Therapeutic information
Type
Filming
Frequency
Outcome information
Patient centred
Measurable
Treatment related

To identify which measures achieve *focus* as defined within the specification, the physiotherapy process in

stroke rehabilitation must be considered. The process of intervention is initiated following referral by a full subjective assessment during which the needs of the patient and or his/her carers are identified as short- and long-term goals to be achieved during physiotherapy. This is followed by an objective assessment in which a physiotherapist uses his or her clinical knowledge to determine whether the goals identified are potentially achievable. It may be necessary at this point to go through a process of negotiation with the patient to identify and agree goals that are individual to that patient's needs and level of impairment, holistic in nature, challenging and measurable.

At this stage, a baseline measure must be established. Treatment plans are determined and subsequently implemented. A means is then required to measure progress towards the achievement of the goals and to monitor the physiotherapy input and its relationship to the patient's progress.

The use of goal setting has been identified by a number of authors (Parry, 1982; Squires *et al*, 1991). Cott and Finch (1991) suggest that it should become an integral part of professional practice, improving treatment effect by providing a negotiated contract of measurable achievement which enables patients to gain maximum benefit.

The ability to measure the achievement of patient-negotiated goals will become an essential component of clinical practice if more hospitals develop patient-focused units. The implementation of patient care plans by generic workers clearly highlights the necessity for a system that enables the measurement of goal achievement during professional input and the effects on that achievement following the implementation of skill mix.

The introduction of national and local patient charters that include the need to discuss and explain procedures prior to treatment, and the potential publication of hospital league tables directly related to the fulfilment of patients' rights according to the charter, further support the need to measure patient-negotiated goals.

Wade (1992b) states that standardised measures are very important in the assessment process where they are used to identify problems and analyse causes. Table 4 illustrates the relationship between some standardised measures and the process of physiotherapy and shows where published measures are appropriate. However, if a goal attainment model of physiotherapy intervention is accepted (Cott and Finch, 1991), it is self-evident that a goal attainment scale should be used in order to demonstrate the effects of physiotherapy on the achievement of goals. Indeed, table 4 highlights the need for a goal-attainment scale such as that provided by TELER.

Parry (1984) and Wade (1992a) discuss the definitions of impairment, disability and handicap developed by the World Health Organisation (WHO, 1980) and the need to identify a model of rehabilitation. Wade (1992a) suggests that if at all possible, measures should be restricted to one level of that definition. The standardised measures are certainly able to achieve measurements of levels as defined; however, the TELER system measures the achievement of patients' needs, whether they are related to impairment, disability or

Table 4: Measurement within the physiotherapy rehabilitation process

<i>Process</i>	<i>Classification</i>	<i>Measure</i>
Assessment: subjective objective	Standardised measures of impairment and disability – ICIDH (WHO, 1980)	National Institute of Health Stroke Scale – NIH (Brott <i>et al</i> , 1989)
Negotiate short and long-term goals: challenging measurable patient-specific	Goal attainment scale.	Teler (Le Roux, 1993)
Establish base line measure. Determine treatment plan		
Implement, monitor progress towards achievement of goals. Re-evaluate goals	Standardised measure of disability (ICIDH)	Barthel Index (Mahoney and Barthel, 1965)
Re-assess prior to discharge or transfer	Standardised measure of handicap (ICIDH)	Rankin scale (Rankin, 1957)

Adapted from Cott and Finch (1991)

handicap.

While the use of goal attainment scales in the management of conditions such as chronic pain (Williams and Steig, 1987) has been documented, they are rarely used in physiotherapy. The TELER method, which is currently being used as a system to evaluate practice in a number of health authorities such as Barnsley, Central Nottinghamshire, and North Lincolnshire, enables the measurement of goals of individual patients through the development of TELER indicators (Le Roux, 1993). The system has the ability to provide the vital link between input, staff mix and goal attainment. It facilitates clinical audit using indicators that are patient-specific, thus fulfilling the needs of managers, clinicians and patients.

Conclusion

This qualitative study was carried out on the stroke unit at the NGH to provide information regarding specifications for a measure of outcome from physiotherapy. Existing measures were identified and compared with the defined specifications. It appears from this study that the TELER system using TELER outcome indicators fulfils all the specifications required.

The TELER system with incorporated classification scales (NIH, 1989; Rankin, 1957) will be piloted on the stroke unit at the NGH to establish the feasibility of using the system to audit clinical practice and to identify the characteristics of effective physiotherapy intervention.

Following this pilot study and in conjunction with physiotherapists in other health authorities, it is anticipated that normal movement (Bobath, 1990) indicators will be developed with clinically significant increments within the scale of measurement. Once

consensus regarding clinical significance has been achieved, the construct and content validity of the indicators will be assessed in a randomised control trial using the TELER system and the Barthel Index. A reliable and valid measure of physiotherapy outcome in stroke rehabilitation will then be available for research into the effects of physiotherapy and the possible patterns of recovery during the implementation of physiotherapy.

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The Validity of Using a Force Platform to Measure the Forces Applied During a Postero-anterior Mobilisation of the Lumbar Spine

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The purpose of this study was to determine the validity of using a force platform to measure the minimum and maximum forces, amplitude and frequency of oscillation during a postero-anterior (PA) mobilisation of the lumbar spine.

An experienced physiotherapist stood on a Kistler force platform and applied a simulated PA mobilisation for 20 seconds to one arm of a digital pinch grip analyser (PGA) which was secured to a portable treatment couch.

The test was repeated ten times and minimum and maximum forces for each oscillation were measured simultaneously by the PGA and force platform. Two-tailed paired t-tests were carried out to compare the readings from the PGA and force platform.

The force platform overestimated the applied force by less than 4N, an error of 3.7%. The force platform underestimated the amplitude of oscillation by less than 1N, an error of 2.3%. These errors were considered to be small.

The force platform accurately measured the frequency of the oscillation. It was therefore concluded that the force platform is a valid tool with which to quantify PA mobilisation.

The TELER Indicator

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A TELER indicator is a six-point measuring scale. Unlike other measuring scales used by physiotherapists the TELER indicator satisfies the requirements of the theory of measuring scales. This means the codes which denote the points on a TELER indicator are defined to have the properties of connectivity, asymmetry and transitivity. These properties are described. The effect when they are lacking is illustrated by reference to an existing measuring scale.

Unlike other measuring scales used by physiotherapists the TELER indicator satisfies the requirements of the theory of appropriate statistics. This means the TELER indicator is not a composite of a set of subscales,

and requires that the codes for the points on a TELER indicator are defined to have the property of uniqueness. This property is described. The effect when it is lacking is illustrated by reference to an existing measuring scale.

Measuring scales which do not satisfy the requirements of the theory of measuring scales and the theory of appropriate statistics are nevertheless useful for studying groups to obtain information for the purposes of managing a service. The reason for this is explained.

The TELER indicator, on the other hand, is useful for studying individuals rather than groups, because it satisfies the requirements of decision theory. It does so because certain assumptions have been made about the nature of the healing process. These assumptions are listed. Their effect is described.

TELER Indicators or Barthel Index: A validation study

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The purpose of this presentation is to outline the process undertaken to develop and validate a series of TELER functional indicators to be used for physiotherapy research in neurological rehabilitation.

A TELER indicator is a six-point ordinal scale. The

codes which denote the points on the scale are composed of clinically significant functional steps required to achieve a given goal.

To establish face and content validity 54 patients admitted into five stroke units with a Rankin score of 4 or 5 over a 12-month period were asked to define their functional goals. These were then developed into the six-point ordinal scale of the TELER indicator by five senior physiotherapists ensuring that the defined codes fulfilled the theoretical basis of the TELER indicator. The indicators were further critiqued by the national

Bobath tutors group in a consensus meeting prior to the final validation process to assess the construct and predictive validity of the indicators.

This last stage is presently under way in ten national stroke units with 26 physiotherapists using a cross-over design scoring patients on the TELER indicators, the

Barthel Index, the Motor Assessment Scale and the US National Institute of Health stroke scale.

The results of the initial phase will be presented together with a summary of the potential values of the measuring system for research within the areas of neurological rehabilitation.

Demonstration of High Intra-tester and Inter-tester Reliability of Analysis of Strain Gauge Plethysmography Traces for Measurement of Blood Flow

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P McCoy

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Strain gauge plethysmography is a technique for measuring arterial blood flow. Arterial blood flow is translated as a curve on a polygraph and is calculated as a function of the tangent of the initial part of the curve. The following method is based on a review of techniques quoted in the literature.

A point is marked at the foot of the initial pulse of the upward slope of the plethysmography curve. At 0.5 cm horizontally from this point a vertical line is drawn to intersect the curve. A point is marked at the foot of the pulse closest to the intersection. The gradient of the line between the two marked points is regarded as the curve tangent.

Intra-tester reliability: Four different curves were photocopied five times each, each photocopy on a different piece of paper and coded. The curve tangents were analysed and blood flow values calculated. The curves were decoded and grouped. Each group contained a copy of each of the four original traces.

The mean values were calculated for each group and showed high Pearson's product moment correlations ($0.997 \leq r^2 \leq 1.000$) and coefficients of determination ($0.997 \leq r^2 \leq 1.000$).

Inter-tester reliability: Three different curves were copied five times. A copy of each was given to five subjects who calculated blood flow readings using the above method.

The means of the three scores for each subject were compared and found to have high Pearson's product moment correlations ($0.891 \leq r^2 \leq 1.000$) and coefficients of determination ($0.794 \leq r^2 \leq 1.000$) for each group pair.

A Modified Chaffin Life Evaluation Record for Use in Children: Reliability and validity

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The reliability and validity of a video-based observational method incorporating the Chaffin Life Evaluation Record (LER) for the assessment of a dynamic lifting task in prepubescent children were determined.

Data were collected from 12 subjects performing a simple lifting task; the intra-observer reliability was found to be high using chi square. The LER was then modified to define squat (trunk 0° to 30° from vertical), semi-squat (trunk 35° to 60° from vertical) and stoop (trunk greater than 65° from vertical) lifting postures, and tested on data from 18 children (mean age 7.5 yrs \pm 0.4). Intra-observer reliability was found to be consis-

tently high for both the Chaffin and modified LER.

To establish its validity, the modified LER was compared with knee and torso angle data derived from digitised video recordings, and found to be good. Intra-subject consistency was also observed to be high across all subjects in the performance of two lifting tasks, each three times.

While they are simple measures, both the Chaffin and the modified LER are reliable and indicate the overall lifting pattern. Further analysis using the modified LER with the data of the present study clearly shows that within a dynamic lifting task, in children at least, a series of postures is adopted with major differences being apparent between the descent and ascent phases and with age. The modified LER together with the knee and torso angle data suggests that prepubescent children predominantly adopt stoop and semi-squat postures with stoop more evident as age advances.

Results: A total of 3,700 data sets were collected and analysed. The instrument has been fully incorporated into departmental recording systems. Uses of the instrument have been identified as:

- Measuring effectiveness of physiotherapy outcomes.
- Offering quantifiable data which can be used in patient profiling.
- An educational tool for junior and less experienced staff in terms of realistic goal setting, documentation and choice of therapeutic programmes.
- A base-line measurement tool for future clinical research.

Conclusions: The tool has been shown to have face validity among its users and to be user-friendly. It provides useful information for clinicians, patients and managers about progress and effectiveness of treatment and possible confounding variables and their effect on outcomes of therapy.

Full inter- and intra-therapist reliability studies are currently under way.

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TELER

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The aim of the study is to provide a unique method of clinical note-taking. Such a method uses measuring scales which have the properties required by the theory of measuring scales (Stevens, 1946; Senders, 1958), and clearly shows how a patient changes while under treatment. The purpose of the method is to facilitate effective delivery of treatment, effective management of the treatment service, and effective clinical audit.

The conventional clinical notes for a patient are rewritten in TELER format, and the two sets of notes are compared from a therapist's and a manager's perspective.

The requirements of the theory of measuring scales are analysed to determine how they can be satisfied. A simple 'test of construct validity' is presented. A validated TELER indicator is also presented. The term 'indicator' is used to show that a TELER measuring scale is unlike any existing scale available for use in physiotherapy.

The comparison of the conventional and TELER

methods of clinical note-taking shows that in both the therapist's and the manager's perspective all the advantages are with the TELER method, and all the disadvantages are with the conventional method.

The 'test of construct validity' is used on the Barthel ADL index, and shows that it, for example, provides the therapist with virtually no useful clinical information.

The extent to which TELER has an acceptable level of validity is shown by enumerating the professional groups which use TELER, the clinical areas in which they use TELER, and the approaches in which they use TELER. The geographical distribution of TELER users is also given.

Experience over 2½ years of use shows that TELER is an effective replacement for the conventional method of clinical note taking, and results first in a significant improvement in the quality of treatment delivered, and secondly in a significant saving of valuable clinical time.

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Measuring the Outcome of Stroke Rehabilitation: A validation study

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Aims: The initial aim of this three-year study was to develop a set of TELER (Treatment Evaluation LeRoux method) outcome indicators (Le Roux, 1993) to be subsequently used to evaluate the outcome of stroke physiotherapy. Following the initial development of the indicators, their concurrent validity was assessed in a study comparing scores obtained using TELER and by

the Motor Assessment Scale MAS (Carr *et al*, 1985; Poole and Whitney, 1988). The aim of this phase was to establish whether the indicators measured similar functional tasks and which of the two measures provide information that could be used in an effective clinical audit.

Design: The initial phase to develop the 'face' validity of the TELER indicators was carried out on five stroke units in a patient-oriented task analysis of functional goals by senior Bobath-trained physiotherapists. The task components became the six points of the TELER ordinal scale, each definition of which denoted an observable clinically significant step in the recovery of the patients' functional skill. The British Bobath Tutor

Association was subsequently involved in a consensus meeting when agreement was reached regarding the components of the indicators.

The final validation process to establish the concurrent validity of the indicators involved ten stroke units and 20 senior physiotherapists in a cross-over design using the two measures of motor function.

During the validation process a total of 69 patients were included in the study.

Results: Data were analysed using Spearman rank correlation coefficient. High correlations were obtained between the MAS and TELER scores for individual items ($r = 0.36$ to 0.99) 67% of the scores falling into a range of $r = > 0.9$. Of particular interest were the high levels of correlation found between the sitting, sit-to-stand, walking and upper arm function scores. Further analysis using the chi square test demonstrated that the TELER indicator was more sensitive to change, particularly in the measurement of standing and stepping.

A consolidation and acquisition pattern of motor recovery was identified in 29 patients, the pattern being statistically significant using a chi square test analysis.

Conclusion: The TELER indicators developed during this study are a valid measure of motor recovery following a stroke. They are more sensitive to changes in certain motor functions than the MAS. A pattern of recovery during rehabilitation by Bobath physiotherapists was identified, which may provide some evidence of the theoretical basis underlying the approach.

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A Patient-specific Approach for Measuring Functional Status in Low Back Pain

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Objective: To develop and evaluate a patient-specific approach to measuring functional status in low back pain.

Methods: At baseline patients selected their main complaints in a standardised way: they selected three activities they performed frequently, which they perceived as important in day-to-day life, and which low back pain made difficult for them. A cohort of 150 patients with non-specific low back pain scored their main complaints at baseline and 12 weeks later on a 100 mm visual analogue scale.

The feasibility of this procedure was evaluated. Effect size statistics and correlations between change scores were used to evaluate the responsiveness. The results of the patient-specific approach were compared with more established instruments such as the Roland disability questionnaire and pain during the past week evaluated on a visual analogue scale.

Results: The patient-specific approach was feasible, it was easy to understand and the time required to complete it was short. Patients appreciated that attention was paid to their specific situation and that they could select the complaints of importance to them. The responsiveness of the patient-specific approach was good and comparable with that of more established outcome measures. The patient-specific approach was able to discriminate between improved and non-improved patients. The correlations between change scores were high.

Conclusion: The patient-specific approach was able to detect changes on complaints that were highly relevant for an individual. It would be valuable to apply the patient-specific approach in future studies to try to replicate our results and provide further evaluation.

What is the SF-36 and Can It Measure the Outcome of Physiotherapy?

Sue Mawson

Introduction

The SF-36 is a health status questionnaire developed in the United States by the Medical Outcomes Study (MOS) and adapted for use in the UK in 1990. The initial questionnaire consisted of 36 items developed from a longer questionnaire, hence the title SF-36 denoting a 'short form' version of the original measure. While usually administered as a self completed questionnaire, a version for administration by interviewer is available through the MOS Trust in Boston. The UK version and scoring manual are available free of charge from the UK Clearing House on Health Outcomes at the Nuffield Institute for Health, 71-75 Clarendon Road, Leeds LS2 9PL.

This new measure of health status has been extensively marketed to both purchasers and providers throughout the health service and is being presented as the outcome measure of choice in a number of national projects to identify changes in health status following surgical procedures such as total hip and knee replacements (Gwent Health Commission, Gwent; Somerset Health Authority, Taunton) (Dixon *et al*, 1994).

As the SF-36 is obviously a popular measure of health status it is important for physiotherapists first to understand what the questionnaire contains and, secondly, to judge its value as a tool for assessing the outcome of physiotherapy intervention. This article addresses both questions and makes recommendations for its use to managers and clinicians seeking ways to measure the effects of service provision.

What Does the Questionnaire Measure?

When measuring patients' quality of life following changes in health status, it is important to include certain core domains such as physical, social, psychological and occupational well-being, all of which are relevant and may have been altered by changes in health (Fallowfield, 1992).

The UK version of the SF-36, obtained from the Medical Research Unit, University of Sheffield

Medical School, consists of eight core domains which include 35 items covering a variety of topics from climbing stairs to levels of nervousness, tiredness and pain. As shown in table 1, a supplementary question asks about any change in health in the last year.

Table 1: The domains of the SF-36 (Dixon *et al*, 1994)

Domain	No of items	Topics covered
Self-reported general health	5	Rating of own health Comparison with other people's health Comparison with others' proneness to illness
Physical functioning	10	Extent to which health limits ten levels/types of physical activity: Three items refer to walking Two to climbing stairs Two to bending and stretching One to combined movements
Mental health	5	Degree of nervousness/calmness Degree of happiness/sadness
Role limitations – physical	4	Limits that physical health puts on range and extent of all types of work
Role limitations – emotional	3	Limits that 'emotional problems' put on range and extent of all types of work
Bodily pain	2	Severity of pain Impact on activities
Energy/tiredness	4	How energetic/tired
Social functioning	2	Impact of physical health or emotional problems on 'normal' social activities
<i>Supplementary question</i>		
Change in health in past year	1	Single unscored item comparing health now with 12 months ago

Can the SF-36 Measure Physiotherapy Outcomes?

To determine how valuable this measure is to the physiotherapy profession it is important to establish whether the SF-36 is:

- A valid measure of physiotherapy outcome.
- A reliable measure of physiotherapy outcome.
- Sensitive to changes induced by physiotherapy intervention.
- Feasible for use in clinical practice.

Validity

Although several types of validity are discussed in the literature (Wade, 1992; Stewart and Ware, 1992), it is true to say that a measure is valid if it measures what it purports to measure. As a measure of general health status for a population of healthy individuals, the SF-36 has some reported evidence of its validity (Brazier *et al*, 1992). A number of studies have attempted to establish criteria and construct validity (Jenkins *et al*, 1994). However in a recent article published by the Health Outcomes Clearing House, Dixon *et al* (1994) suggested that there might be flaws in the arguments regarding the true validity of the questionnaire, particularly in relation to specific patient groups such as the elderly.

The fundamental question remains regarding the ability of the SF-36 to record changes in health status that can be attributable to physiotherapy intervention. In other words: Can it be used to measure the outcome of physiotherapy?

Measuring the Effects of Intervention on Physical Functioning

To answer the above question, the items within the SF-36 that relate to physical well being must be examined to determine their validity as it is these domains that may be affected or altered by therapeutic input and, potentially, used as measures of physiotherapy outcome. Domains specifically relating to functional status are:

- Physical functioning (ten items).
- Role limitation physical (four items — during the *past four weeks*)
- Social functioning (two items — *normal social activities*)

According to Wade (1992): 'Construct validity refers to the extent to which results obtained using the measure concur with the results predicted from the underlying theoretical model.' The theoretical model on which this questionnaire is based is a medical model of intervention and recovery, ie illness → treatment → recovery. It is therefore assumed that patients will, following intervention, be restored to not only full but significantly advanced functional and social skills. For example, the lowest level of functional ability recorded on the SF-36 is the ability to play golf (see table 2). While this may be suitable for certain client groups such as post-operative meniscotomy or laminectomy patients, in other conditions for which the models of intervention are very different, its use is doubtful.

Table 2: Health and daily activities (from SF-363 University of Sheffield, Medical Care Research Unit)

The following questions are about activities you might do during a typical day. Does your health limit you in these activities? If so, how much?

Please tick one box on each line

	Yes. limited a lot	Yes limited a little	No. not limited at all
(a) <i>Vigorous activities</i> Such as running, lifting heavy objects, participating in strenuous sports	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(b) <i>Moderate activities</i> Such as moving a table, pushing a vacuum cleaner, bowling or playing golf	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(c) Lifting or carrying groceries	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(d) Climbing <i>several</i> flights of stairs	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(e) Climbing <i>one</i> flight of stairs	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(f) Bending, kneeling or stooping	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(g) Walking <i>more than a mile</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(h) Walking <i>half a mile</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(i) Walking <i>100 yards</i>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(j) Bathing and dressing yourself	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

As the medical model is not necessarily the theoretical model underpinning physiotherapy intervention (see Roberts, 1994) to use a questionnaire based on it would, as Wade (1992) implies, inevitably mean that it was not a valid measure of physiotherapy outcomes. To establish whether the SF-36 can measure the predicted response to physiotherapy the models of intervention that differ from the proposed medical model must be identified:

Patients with chronic illnesses and irreversible pathologies, who cannot achieve any of the advanced functional skills included in the SF-36 and whose functional status is improved by intervention but, due to irreversible pathologies, will never achieve any high level of function. For example patients suffering from chronic obstructive airways disease (COAD) who, following hospital admission, can dress without the use of oxygen support and walk to the lavatory independently; late stage Parkinson patients who, following intervention, can rise from a chair, move in bed and therefore sleep unattended; and spinal injury patients who, following extensive therapy, can transfer from bed to chair independently, manoeuvre kerbs and uneven surfaces, etc. Such activities which enable independent living are not recorded in the item on physical impact on the SF-36.

Patients with terminal illnesses and progressive pathologies, for whom the role of physiotherapy is to maintain their functional status whatever that may be. Very few multiple sclerosis patients for example would score anywhere near the predicted norms on which this questionnaire is based. However, physiotherapy may bring about clinically significant changes in function and maintain the patients' ability to cope with their disabilities.

Patients receiving health education, for whom the role of physiotherapists is educational and the outcome of intervention is an increase in knowledge levels. For example back school pupils, rheumatoid arthritis groups, ante-natal groups, cardiac rehabilitation classes, children who are taught to use spinhalers.

Measuring the Effects of Intervention on Body Pain

If the measure of physical status is not a valid measure of most physiotherapy intervention processes, the question then arises as to whether any of the other core items can be used to measure physiotherapy outcome. The measure of pain is pertinent to outcome from physiotherapy (table 3).

Table 3: Pain items measured by the SF-36 (from SF-363 University of Sheffield, Medical Care Research Unit)

Please tick appropriate box

How much <i>bodily</i> pain have you had during the <i>past four weeks</i> ?	None	<input type="checkbox"/>
	Very mild	<input type="checkbox"/>
	Mild	<input type="checkbox"/>
	Moderate	<input type="checkbox"/>
	Severe	<input type="checkbox"/>
	Very severe	<input type="checkbox"/>
During the <i>past four weeks</i> , how much did <i>pain</i> interfere with your normal work (including work both outside the home and housework)?	None	<input type="checkbox"/>
	Very mild	<input type="checkbox"/>
	Mild	<input type="checkbox"/>
	Moderate	<input type="checkbox"/>
	Severe	<input type="checkbox"/>
	Very severe	<input type="checkbox"/>

A number of theoretical models of physiotherapy intervention specifically identify the effects of treatment on patients' perception of pain. For example, the approaches of Maitland, McKenzie and Cyriax rely heavily on patients' interpretation of pain levels as a measure of their therapeutic outcomes. Again, however, this is usually related to their functional skills. Occasionally these may be high level activities but more frequently patients complain of pain affecting activities such as driving, typing, sleeping or moving.

The time period for recording changes in pain levels is also an important theoretical concept when using the therapeutic models presented. How clinically significant is it to the patients to record pain or the effect of pain over the past *four weeks*?

Without information regarding other factors that may influence the patients' perception of pain, it is totally unacceptable to use this time span or indeed this section of the SF-36 as a measure of physiotherapy outcome. Four weeks may be significant to the 'normal', ie healthy, population but to chronic pain sufferers this is not clinically significant. Nor is it so for patients with acute sports injuries for whom time span may be related to length of training.

Yet again, it can be seen that the limitations of the SF-36 are considerable, since few patients are predicted to return to such advanced function. For a large proportion of patients referred to physiotherapy practitioners this is not an acceptable measure of outcome as it would not record changes that may be very significant for the patients but produce no statistically significant changes in aggregated data.

Reliability

The reliability of a measure relates to the ability to reproduce the results of the measure and can relate to qualities of the measure and the measurer (inter- and intra-rater reliability). The reliability of a measure is usually established by reproducing the results over a period of time within similar settings. However, with health status questionnaires this is a difficult task and, as Dixon *et al* (1994) state: 'Most of the evidence comes from tests of internal consistency which may over-estimate true reliability.'

Another important issue is the reliability of patient responses: Are they able to fill in the form? What is their perception of health? And what factors may alter their perception and attitudes of health?

Sensitivity

The sensitivity of a measure relates to its ability to record and detect anticipated changes. As discussed earlier, the functional levels measured by the SF-36 are gross and unlikely to record changes that are, in fact, clinically significant for many patients treated by physiotherapists.

To establish whether a measure is sensitive or responsive to changes that may be induced by the intervention to be evaluated, both the starting and end points should be identified, together with the levels of measurement and the increments of change within the scale. As the starting point for physical activities in the SF-36 is the ability to play golf or move a table, there would be a significant 'floor effect' for a large number of patients, ie although change had been induced, their end

points would fall below the levels measured.

Even with moderate activities that include pushing a vacuum cleaner and bathing or dressing, the measurement of change in limitation is: 'limited a lot', 'limited a little' or 'not limited at all'. This is a non-parametric ordinal scale and there must be considerable concerns regarding its level of responsiveness to clinically significant change. Therefore, a further question should also be addressed regarding the method by which this questionnaire is analysed, because total scores are used to aggregate data, a method which disregards the theory of measuring scales (Stevens, 1946) and the theory of appropriate statistics (Adams *et al.*, 1965).

The Theoretical Basis of Measurement

The theory underlying all measurements consists of three main components:

- The theory of measuring scales.
- The theory of appropriate statistics.
- The theory of error.

These theories if fulfilled ensure that a measure means what it says, in effect they require that each point on a scale is defined to provide a unique meaning. Once this requirement has been satisfied the theory of measuring scales also requires the defined points on the scale to be hierarchical if the scale is ordinal, interval, or ratio. Are these two requirements satisfied by the SF-36?

Hierarchy: This theory states that any scale purporting to be an ordinal scale must have an hierarchical progression from one point on the scale to another. While this is true of the levels of limitation there is a very dubious hierarchy within the individual items. Our clinical knowledge tells us that the list of skills (a) to (j) are not in any hierarchical order and should not therefore be used as ordinal data or — worse — summed and aggregated to produce interval data that have no clinical significance.

Uniqueness: This theory relates to the individual value of a score within a scale. For example with an interval scale such as degrees centigrade where there is no true zero but the steps between each degree of temperature are equal, 15°C is unique. It is not 14°C nor is it 16°C.

Similarly with a *ratio scale* such as height where there is an absolute zero a measurement of four inches is unique. It is neither six inches nor is it three inches.

The individual items within an *ordinal scale* should also be unique, however. Once data are summed, the ordinal scale loses its uniqueness (see table 4).

Table 4

	Extent of limitation		
	A lot	A little	Not at all
(i) Walking 100 yards	0	1	2
(j) Bathing and dressing yourself	0	1	2

Respondents may achieve a summed score of 0, 1, 2, 3 or 4. Would a score of 2 be unique? Obviously not, as a score of 2 could indicate a combination of 2 + 0, 1 + 1, or 0 + 2.

Whenever ordinal scores are summed, as appears to be the case with the SF-36 and is definitely so with other functional indexes such as the Barthel Disability measure (Mahoney and Barthel, 1965), the resultant analysis can be extremely inaccurate and misleading, particularly if this information is used to determine resource allocation as with the SF-36.

Feasibility

It is essential in clinical practice not only to be able to record clinically significant changes in health status but also to be able to measure changes over time, particularly if there is any hope of using the information to attribute the changes to intervention (Le Roux, 1993) or to identify the relationships between contributors in multi-disciplinary health care. If the SF-36 is used before and after intervention to determine the outcomes, for example following hip replacement, it is impossible to establish whether the improved health profile was the result of:

- The type of prosthesis used.
- Post-operative physiotherapy.
- Adequate post-operative analgesia.
- Provision of required anti-depressants.
- Environmental adaptations provided by occupational therapists.

In a study undertaken in Barnsley District Health Authority, length of stay on the orthopaedic ward was used to assess the outcome of physiotherapy. However, following the use of an alternative outcome measure that recorded clinically significant changes over time, it became apparent that the length of stay had been prolonged to achieve wound healing as indicated in the nursing protocol (Bullock, 1994).

This example highlights the dangers of using stand-alone measures that do not fulfil the theory of measurement or provide information about patterns of change over time. Even in areas where it is anticipated that the patient will recover full function, the value of this information to health

economists is questionable if the relationship between input and outcome within the care team cannot be identified.

Recommendations for Using the SF-36

The purpose of this article was to establish whether this generic health questionnaire should be used to measure the outcome of physiotherapy treatments. There should now be little doubt about its lack of validity or sensitivity or its inadequate properties as a measure of therapeutic intervention.

However, where it is perceived that patients may be restored to full function as a result of physiotherapy, GP referrals to out-patient physiotherapy departments for example, then the SF-36 may be of value as long as those using the measure are aware of its inability to demonstrate attribution to therapy because change is not recorded over time.

It may be that the questionnaire can be modified without losing its validity as a generic health measure. The function items recorded could be altered to fit the client group to be evaluated or the time period for recording pain levels could be altered to make this aspect more clinically significant to the patient.

Further work needs to be done, first to establish which types of patients this questionnaire is suitable for and, secondly, to modify the questionnaire to fit the needs of specific clients and fulfil the conceptual and theoretical models of physiotherapy intervention.

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