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A centralization and directional preference : a systematic review

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Table 1. Description of studies into centralisation (N =62)

Author	Purpose / Study design	Participants	Outcomes	Results
Abdulwahab & Beatti 2006	Evaluate effect of prone lying & IFT / Observational	28 patients with DH & 28 controls	H-reflex, pain severity & distribution	No change in H-reflex change in severity & distribution (p<0.001).
Broetz et al 2003	Evaluate effect of MDT / Observational	50 patients with DH & Cen in 5 sessions	Pain, neurology & satisfaction at 6 weeks / 1 year	Pain in only 29% / 11%, satisfaction 81% / 93% at 6 weeks / 1 year
Broetz et al 2008	Evaluate effect of MDT / Observational	11 patients with DH	Pain, neurology & pain distribution at 50 days	10 / 11 centralised
Broetz et al 2010	Evaluate long-term effect of MDT / Observational	40 / 50 from 2003 study, 6 of rest had disc surgery	Pain, neurology & satisfaction at1/5 years	Pain 11% / 23%, satisfaction 93% / 82%

Browder et al 2007	Cen in response to extension repeated movements used as inclusion criteria for RCT	48 patients with LBP with referral below buttocks randomised to 1)extension or 2) strengthening	Cen, pain & function at 1, 4 weeks & 6 months	1) V 2) function better all time points (p= 0.01, 0.004 & 0.005); pain better 1 week (p=0.007); Cen 1& 4 weeks
Bybee et al 2005	Relation between Cen & pain during movement (PDM) / Association	33 patients with LBP	Relationship between Cen & PDM	PDM associated with Cen p=0.038
Bybee et al 2009	Relation between Cen & ROM / Association	42 with LBP with referred symptoms	ROM inclinometer at up to 3 weeks	Cen group = 33; more extension ROM p<0.001
Christiansen et al 2009	Relation between Cen & psychological factors / Association	331 sick listed patients with LBP +/- referral	Correlation between Cen/ non-Cen and psychological factors in cross-section analysis	Cen group = 30%. Regression analysis confirmed non-Cen group correlated with

				mental distress and depression (p=0.013 and 0.044)
Christiansen et al 2010	Association between Cen & RTW / Prognosis	351 sick-listed patients with LBP +/- referral	Return to work at 1 year	Cen = 30%; periph = 8%; no response = 62% No differences in RTW, pain or disability.
Cleland et al 2006	Cen used as outcome measure in RCT	30 patients with positive slump test & negative SLR randomised to mobs, exercise or mobs, exercise & slump stretching	Oswestry, pain, cen	Slump group better Oswestry (p=0.001), pain (p=0.001), & Cen (p<0.01)
Delitto et al 1993	DP in response to Ext as criteria for trial / RCT	24 patients with ALBP randomised to Ext or	Oswestry at 5 days	DP = 61%; Ext responded better

		Flexion		
Dionne et al 2006	Reliability study of McKenzie assessment	54 therapists viewed videos of 20 patients with neck pain	% agreement, kappa, p-value for accuracy	DP = 70% agreement, (p<0.05), kappa =0.46.
Donelson et al 1990	Prevalence & prognostic value of Cen	87 patients acute to chronic LBP	Outcome based on complete recovery / improvement, RTW & satisfaction / pain relief only / no change	Cen = 87%; Cen & excellent/good outcome (p<0.001); non-Cen & fair/poor outcome (p<0.001)
Donelson et al 1991	Loading strategy to induce Cen / Association	145 patients acute to chronic LBP	Which sagittal plane movement induced Cen	Cen = 47%; 40% = extension; 7% = flexion
Donelson et al 1997	Criterion validity against positive discography /	63 patients with CLBP	Correlation between Cen status & discography	Cen = 49%; Cen / Periph positive

	Validity		findings	discography (p<0.007);
				Cen 21/23 competent
				AF (p<0.001)
Edmond et al 2010	2nd analysis of previous cohort study to compare predictive value on Cen & depression / somatisation / Association	231 patients with LBP	Function, pain & work status at discharge & 6 & 12 months	Presence of Cen confounds association between depression & somatisation on chronic pain & disability.
Erhard et al 1994	DP in response to Ext for trial / RCT	27 patients randomised to manipulation or Ext	Oswestry at 5 days	DP = 55%; better response to manipulation
Fritz et al 2000	Interrater reliability of judgements about Cen	40 physical therapists & 40 student PTs viewed videotape of 12 exams	Reliability of judgements about Cen status during repeated movements	Overall kappa =0.79 PTs =0.82, students =0.76

Fritz et al 2003	Comparison of CBT, including DP, versus guideline-based treatment / RCT	78 patients with acute LBP randomized to 1) CBT or 2) guidelines	Pain, function, SF-36 depression, fear-avoidance, work status at 4weeks, 6months, 1year	At 4 weeks 1 > 2 Oswestry p=0.02, SF-36 p=0.03, work status p=0.02. 1year NSD
Fritz et al 2006	Interrater reliability of classification system that included Cen	60 patients with stable LBP between 2 exams	Reliability of judgements about Cen status during repeated flexion, extension & sustained extension	Kappa = 0.46, 0.15 & 0.28
Fritz & Brennan 2007	TBC system in patients with neck pain (NP) / Observational	274 patients with NP classified according to TBC groups	Prevalence rates, reliability, and value of matching treatment to group	Cen group = largest 35%; received matched treatment better pain & function outcomes
George et al 2005	2ndary analysis from	28 patients classified	Disability and pain at	No Cen / high FAB-

	previous trial of Cen & FAB to predict outcomes / Prognosis	with specific exercise	6 months	work predicted disability (p=0.003 / 0.027); no Cen predicted pain (p=0.031)
Hefford 2008	Survey of 34 therapists reporting 10 patients classification & DP / Observational	321 patients with LBP (187), NP (111), & thoracic pain (23)	MDT classification & DP	78% = derangement; DP extension (180), flexion (16), lateral (54)
Karas et al 1997	Prospective study prevalence & prognosis	126 patients acute to chronic LBP	Return to work	Cen = 73%; better RTW (p=0.038); low Waddell better (p=0.006)
Kilby et al 1990	Reliability study into a 'McKenzie algorithm'	41 patients with LBP were examined by 2 physiotherapists	% agreement & kappa values	Cen = 90% agreement, kappa = 0.51

Kilpikoski et al 2002	Reliability study of MDT assessment	39 patients with LBP examined by 2 physiotherapists	Kappa values	Cen = 0.7; DP = 0.9
Kilpikoski et al 2009	2ndary analysis of previous trial in Cen group	119 patients with LBP & Cen randomised to MDT, OMT, advice	Pain & disability 3, 6 months & 1 year	MDT & OMT some significant differences V advice especially at 6 months; MDT V OMT leg pain at 3 months (p=0.011), function (p=0.028)
Kilpikoski et al 2010	2ndary analysis of previous trial between Cen / non-Cen groups	119 patients with LBP = Cen; 15 = non-Cen randomised to MDT, OMT, advice	Pain & disability 3, 6 months & 1 year	After treatment LBP & disability better in Cen (p=0.033 & 0.001); 6 months LBP better in Cen (p=0.041)

Laslett et al 2005	Cen as predictor of +tive provocation discography & influence of disability & distress / Validity	69 patients with CLBP who tolerated full exam & discography	Sensitivity, specificity & positive likelihood ratios (PLR) for Cen	Sensitivity = 40%, specificity = 94%, PLR = 6.9; values were less in presence of severe disability or distress
Laslett et al 2006a	Using Cen & other variables to see which best predict positive discography / Validity	117 patients with CLBP who received discography	Sensitivity, specificity & positive & negative likelihood ratios for variables	Any 2 of Cen, CLBP, loss of extension, 'vulnerability' in early flexion = 37%, 100%, 6.7, 0.73
Laslett et al 2006b	Cen & other variables as predictors of response to lumbar ZJ blocks / Validity	120 patients with CLBP who received ZJ blocks	Sensitivity, specificity & positive & negative likelihood ratios for	Absence of Cen = 100%, 14%, 1.2, 0.0
Lisi 2001	3 case studies: 2 with Cen at baseline, one non-Cen	3 patients with LBP & sciatica treated with manual therapy	Patient reported outcomes & surgery	2 Cen patients resolved with treatment; 1 non-Cen failed & came to sugery

Long 1995	Prognostic value of Cen in CLBP	223 patients with CLBP	Pain, Oswestry, return to work	Cen better pain (p<0.05), Oswestry (NS), return to work (p=0.034).
Long et al 2004	RCT of patients with DP at baseline	230 of 312 patients with LBP randomised to DP, opposite to DP, or general exercises	Pain, function, tablets, depression, self-rated improvement at 2 weeks	DP better: LBP (p<0.001), leg pain (p<0.003), function (p<0.01), depression (p=.009), self-rated improvement (p<0.005).
Long et al 2008	Case series of non-responders to non-DP changing to DP exercises	96 patients with LBP who were no better after 2 weeks of non-DP exercise & consent to more treatment	Pain, disability, medication, depression interference after further 2 weeks	All outcomes much better (p<0.001)

Long et al 2009	2ndary analysis of RCT comparing prognostic value of Cen against other baseline measures	241 patients with LBP with complete data: 84 met good outcome criteria	17 baseline prognostic variables were entered in regression analysis	Leg bothersomeness & treatment group effect (p<0.001) only in multivariate analysis
May 2006	Survey of 57 therapists on 578 patients / Observational	578 patients with spine pain	MDT classification	78% = derangement
May et al 2008	2ndary analysis of RCT to determine factors associated with good outcome in McKenzie arm	315 patients with LBP & NP randomised to 1) McKenzie, 2) Solution-Finding Approach	Identifying characteristics of patients who improved (50% reduction in disability) in McKenzie	Multiple logistic analysis Cen = p=0.08; LBP = p=0.04; chronic p<0.001.
Mitchell et al 2001	Prospective RCT comparing distraction	30 patients with LBP & neurological signs	Pain intensity & location & SLR pre & post test	Treatment group less pain p=0.001; more centralization

	to control group			p=0.006; better SLR p=0.005
Murphy et al 2009a	Prospective cohort study using a decision rule that included Cen	78 patients with pregnancy-related LBP	Changes in pain & disability, mean 11 months follow-up	% with Cen not given
Murphy et al 2009b	Prospective cohort study using a decision rule that included Cen	49 patients with DH with mean 14 months follow-up	Changes in pain & disability	Cen = 61%, periph = 8%, NE = 31%; Cen associated with better disability after treatment / long-term (p= 0.068 / 0.022)
Niemisto et al 2004	Cen one of numerous predictive variables considered in 2nd analysis of RCT	204 patients with CLBP randomised to: SMT, exercise & consultation or consultation only	Pain & disability at 1 year	Non-Cen, pain & distress predicted poor outcome in SMT group (model 69%).

Piva et al 2006	Reliability study of passive & active movements & affect	30 subjects with NP	Symptom response: no effect, increase, decrease, centralization, peripheralization	Kappa = 0.25, 0.28, 0.65, 0.69, 0.74, 0.75, 0.76, 0.87 for different movements
Rapala et al 2006	Correlation between Cen and MRI findings / Association	98 patients with DH	Status of DH: 1 = DH but AF intact; 2 = extrusion / sequestration; 3 = no pressure on nerve root	1 = 49; 2 = 46; 3 =3. 90% Cen = protrusions & extrusions; 35% Per = Sequestrations & SS.
Schmidt et al 2008	Prognosis between Cen / non-lasting Cen / Per / NE	793 patients with neck or LBP & radiating symptoms	Outcomes at 1-year back & leg pain, disability, RTW	All groups improved. NS between groups. 18% = Cen
Skikic & Suad 2003	Prospective study of use of MDT /Prognosis	43 patients with LBP	Pain severity, location & ROM after treatment	61.5% = Cen (40% acute, 57.5% sub-acute, 80% chronic). SD in pain &

ROM (p<0.01)

Skytte et al 2005	Prognostic value of Cen	60 patients with sciatica	Pain, disability & surgery up to 1 year	42% = Cen. SD leg pain / disability at 2 months (p<0.001); disability at 1 year (p=0.029); surgery (p=0.01)
Snook et al 1998	Control of early morning flexion activities / RCT	85 patients with chronic LBP baseline monitor for 6 months, randomized to treatment or control for 6 months, then control got treatment	Pain, interference with activity, medication	Treatment group decrease pain intensity p<0.01, days in pain p<0.05, & medication p<0.05; SD for control with treatment
Sufka et al 1998	Prognostic value of Cen	36 patients with acute to chronic LBP	Oswestry, SFS in 14 days	69% = Cen; better SFS scores (p=0.015),

				Oswestry (NS)
Tuttle 2005	Cen, pain and ROM single session correlated with between session changes / Prognosis	29 patients with NP who received manual therapy	Likelihood & odds ratios for predictive value	Odds ratios: Cen 9.2, pain 4.5, limited flex/ext 8.0, limited rotation 21.3
Tuttle et al 2006	Cen, pain and ROM single session correlated overall change / Prognosis	29 patients with NP who received manual therapy	Correlation between change in measures & final outcome	Changes in measures only predicted change in that measure
Werneke et al 1999	Prognostic value of Cen partial-Cen	289 patients with acute LBP or NP	Pain, function, N visits at end of treatment	31% = Cen; 46% = partial Cen; Cen = fewer visits (p<0.001); Cen & partial Cen = Better pain & function (p<0.001)

Werneke & Hart 2001	Prognostic value of Cen	223 patients with LBP	1-year follow-up previous cohort multivariate analysis of 22 variables	Only Cen status predicted pain, RTW, function, health care use p<0.004, & leg pain at baseline sick leave p=0.004
Werneke & Hart 2003	2ndary analysis of cohort to determine Cen at initial & multiple visits	287 patients with LBP	Change in Cen classification over time	45% = Cen initial visit, 97% remained Cen; 55% non-Cen initial visit, 60% = Cen at multiple visits
Werneke & Hart 2004	2ndary analysis of cohort to determine most useful prognostic factor (Cen or leg pain)	171 patients with LBP with/without referral & workers compensation	Predicting pain, disability & work status at intake & 1 year	Both predicted at initial visit; only Cen at discharge & 1 year p<0.001
Werneke & Hart 2005	2ndary analysis of	177 patients with LBP	Non-organic signs, pain	46% = Cen; non-Cen OR for

	cohort to determine if Cen correlated with behavioural signs / Association	& workers compensation	behaviours, fear of activity & somatisation	non-organic signs, pain behaviours, somatisation, fear of work = 9, 13, 2, 3
Werneke et al 2008	Cohort study of Cen and correlation with age and chronicity; and prognosis / Association	418 patients with LBP or NP (76% LBP, 53% chronic, mean age 58)	Pain, disability, N of visits	16% = Cen (acute > chronic, younger > older). Non-Cen associated with worse outcomes & more visits
Werneke et al 2009	2ndary analysis of previous cohort to determine association between Cen & fear-avoidance beliefs	238 patients with LBP	Pain & disability	18% = Cen; Cen present fear beliefs did not impact on outcomes. Non-Cen fear beliefs should be addressed
Werneke et al 2010	Cohort to determine	628 patients with LBP	Classification	43% = Cen, 39% = non-Cen,

	prevalence rate of Cen status & criteria for CPR / Observational			18% = NC = 18%; 67% = Der 13% = MCPR, 7% = SCPR
Werneke et al 2011	Cohort to determine prevalence of Cen & DP and prognostic validity	584 consecutive patients with LBP; 481 with intake & discharge data	Classifications & pain and functional status at discharge	60% = DP; 41% = Cen; rates decreased with age & chronicity. Cen, not DP predicted function; Cen & DP predicted pain.
Williams et al 1991	RCT of loading strategy associated with Cen & peripheralisation	207 patients with LBP randomised to lordosis or kyphosis when sitting over 24 hours	% Cen & Per	Lordosis: 56% = Cen, 6% = Per; kyphosis: 10% = Cen, 24% = Per
Young et al 2003	To identify clinical exam findings associated with	81 patients with CLBP	Variables associated with positive injection	IVD pain: Cen p= 0.025, pain rising from sitting p=0.017,

| IVD, ZJ, SIJ identified by injection / Validity | sensitivity = 47%, specificity = 100% |

AF = annulus fibrosus; ALBP = acute low back pain; CBT = cognitive behavioural therapy; Cen = centralisation; CLBP = chronic low back pain; CPR = clinical prediction rules; DH = disc herniation; DP = directional preference; ext = extension; FAB = fear-avoidance beliefs; IFT = interferential therapy; IVD = intervertebral disc; LBP = low back pain; MCPR = manipulation clinical prediction rule; MDT = Mechanical Diagnosis and Therapy; MRI = magnetic resonance imaging; NE = no effect; NP = neck pain; Per = peripheralization; PDM = pain during movement; OMT = orthopaedic manual therapy; OR = odds ratio; RCt = randomised controlled trial; ROM = range of movement; RTW = return to work; SD = significant difference; SFS = Performance Assessment and Capacity Testing Spinal Function Sort; SCPR = stabilisation clinical prediction rule; SIJ = sacro-iliac joint; SLR = straight leg raise; SS = spinal stenosis; TBC = treatment-based classification; ZJ = zygapophyseal joint.