Compression garments and fabric orthoses for rehabilitation and function: a systematic mapping review.

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Abstract

Background/aims

Compression garments, joint supports and dynamic movement orthoses all use elastic fibres and close-fitting designs and have been researched for their effects on movement. There is little cross-referencing between research into these interventions. This review aimed to improve inter-disciplinary understanding by analysing key characteristics of the published evidence.

Methods

Systematic mapping reviews identify gaps in an evidence base and identify questions for more in-depth reviews. This review was conducted in-line with current guidance. MEDLINE, CINAHL and Sports Discuss were searched for primary research investigating compression garments and orthoses for movement and function. The following search terms were used: "elastane", "spandex", "Lycra", "elastomer*", "Theratog*", "compression", "Neoprene", "orthotic", "orthosis", "shorts", "garment*", "splint", "brace", "sock*" and "stockings". Studies were screened against predetermined criteria and key study characteristics extracted.

Findings

Three hundred and fifty-one studies were selected and analysed. Compression garment research was most common (236 studies), followed by research into joint supports (64 studies) and dynamic movement orthoses (42 studies). Research largely reflects the purpose for which each intervention was originally designed. Common topics investigated include posture and movement control, proprioception and muscle activity. Pressure beneath compression garments was measured in 30% of studies.

Conclusions

The review highlights a need for more robust study designs in patient populations and accurate description of interventions. There is a need for a review on the possible effects of compression and support on movement control which should be used to inform future primary research.

Introduction

Elastic synthetic fibres such as Neoprene and Lycra/spandex are used in form-fitting clothing and a variety of close-fitting fabric orthoses. In recent decades, such orthoses have been developed as adjuncts to rehabilitation and exercise. For example, individually-tailored Lycra orthoses have been used for adults and children with neurological pathologies (Watson et al, 2007) and Neoprene orthoses are used for weak, painful joints (Tiggelen et al, 2008). Currently, different designs tend to be used in different conditions but the underlying mechanisms may be similar. Watson et al (2007) suggested that dynamic movement orthoses may help in neurological conditions by enabling a prolonged stretch to shortened muscles; dampening down excessive, inefficient movement; supporting unstable areas of the body; and enhancing sensory feedback. Similar mechanisms of support and enhanced proprioception are considered important for painful or unstable joints (Webster et al, 2017).

Compression garments are used in clinical populations for managing chronic oedema and supporting venous return in vascular disorders (Rabe et al, 2017). The possibility that improved venous circulation has advantages for exercise performance led to development of compression garments for sport (MacRae et al, 2011). Such garments are claimed to improve recovery following exercise and improve sporting performance (Skins International, 2015).

Research into use of compression garments with healthy athletes has grown significantly over the last decade. Many of the effects investigated may be relevant to patient populations, enabling the sport research to inform clinical research. For example, research has indicated that compression garments may be effective for improving circulation (MacRae et al, 2011), kinematics (de Britto et al, 2016), coordination (Hasan et al, 2017), balance (Michael et al, 2014), proprioception (Ghai et al, 2018) and recovery from exercise (Brown et al, 2017), all of which are relevant to mobility, movement and function across a range of pathologies.

Previous systematic reviews have found no clear evidence that dynamic movement orthoses and joint supports are effective in improving pain, function or quality of life (Coghill and Simkiss, 2010; Duivenvoorden et al, 2015), but there is moderate quality evidence that there is a positive, short-term impact of joint supports on proprioception (Ghai et al, 2016). Systematic reviews for compression garments have been conducted. Effectiveness in improving sport performance is still unclear (Born et al, 2013) but there is moderate evidence that compression can improve recovery from exercise in healthy people (Brown et al, 2017; Marques-Jiminez et al, 2016).

Systematic mapping reviews explore the characteristics of a body of research to determine where gaps exist and are particularly useful where research is disparate (Booth et al, 2012). They can suggest research questions for additional reviews or primary research and can be useful for contextualising more in-depth reviews within the broader literature (Clapton et al, 2009). We conducted the current mapping review to provide insights into the current research in both healthy and patient groups. Currently, research and practice in these areas has little cross-over and such a review might prompt improved inter-disciplinary understanding. The review is timely, partly because of the recent growth in compression garment research, and because of the urgent need for interventions that improve the uptake of physical activity in both the general population and in people with pathologies (World Health Organisation, 2010). Therefore, the primary aim of this mapping review was to determine the extent of the literature around compression garments and fabric orthoses as adjuncts to rehabilitation or for improving function. The secondary aim was to describe the characteristics of this body of evidence.

Methods

Design

This systematic mapping review was conducted according to guidelines published by the Social Care Institute for Excellence (Clapton et al, 2009). Because the aim is to describe a body of evidence, rather than draw conclusions about findings, it is not usual to undertake quality assessment within a mapping review (Booth et al 2012).

Search strategy

One reviewer (NS) conducted searches on MEDLINE, CINAHL and Sports Discuss from inception to June 2017, as shown in Table 1. Earlier scoping searches had used a wider range of databases including AMED, EMBASE, Scopus and Web of Science, however, MEDLINE, CINAHL and Sports Discuss retrieved the same relevant studies but with fewer conference presentations and fewer irrelevant studies. The search was designed to locate studies on the interventions described without specifying specific participant groups, study designs or outcomes. A review of citations highlighted some missing studies investigating fabric orthoses and haemodynamics. Altering the search strategy to identify these studies greatly increased the number of irrelevant records, therefore, additional studies were identified from citations. Citations of all included studies were searched. All studies citing relevant systematic reviews (MacRae et al, 2011; Coghill and Simkiss, 2010; Hammond et al, 2016; Born et al, 2013) and frequently cited fabric orthosis studies (e.g. Blair et al, 1995; Birmingham et al, 1998; Kirkley et al, 1999;Gracies et al, 2000) were identified using Scopus and screened.

Study selection

Studies were selected according to the eligibility criteria below. Title screening was carried out by one reviewer (NS). A second reviewer (DS) examined the excluded titles to ensure relevant studies were not excluded. Full-test screening was performed independently by two reviewers (NS and DS).

Inclusion criteria were:

- Primary research of any design, including case descriptions
- Interventions are garments or orthoses incorporating elastomeric fabrics and without inelastic components, designed to be worn during normal activity as opposed to therapy
- Investigation relevant to mobility, active movement or any type of function.

Exclusion criteria were:

- Reviews and editorials, because the aim was to map primary research only

- Abstracts and conference proceedings, because these frequently lacked sufficient detail on study procedures and measures.
- Studies primarily investigating oedema, lymphoedema and venous disease, because there is a well-established role for compression in these conditions and therefore mapping this research was unlikely to provide novel insights.
- Studies on wound healing, thrombus prevention, acute post-surgical management and orthostatic hypotension because these were felt to have limited relevance to other conditions.
- Studies on interventions designed only for use in therapy sessions, such as the Adeli suit and Therasuit.

There were no disagreements on inclusion so the third reviewer was not used.

Coding and mapping process

Included studies were coded by one of three reviewers (NS, DS and TP) via a standardised online form that had been piloted by these reviewers. Data extracted was author(s), country, year of publication, study design, participants, intervention (defined below), outcome measures and whether pressure beneath the garment was measured.

Interventions were classified as compression garments if compression was described as a feature of the garment; as a joint support if only one joint or body area was covered by the orthosis; and as a dynamic movement orthosis if the garment was not described as a compression garment but where the orthosis covered more than just one body area. Orthoses are defined as externally applied devices used to modify the structural or functional characteristics of the neuromusculoskeletal system (Ponton, 1997). All three interventions could be described as orthoses, however, we chose terminology to reflect descriptions used in the studies.

The mapping process was undertaken by one reviewer (NS) and involved organising all of the studies into themes for ease of description of the body of evidence. Initially, studies were grouped using

their titles and outcome measures and a pattern was identified that themed studies according to their main aim of investigation. Once themed, new codes were created that were felt to best describe each theme and these codes were added to the study database. The final description of the 351 studies was checked and agreed by other reviewers (SMcL, DS, TP, JW).

Results

Study selection

The search found 5408 records, of which 1133 were duplicates; 4275 records were screened by title. Five hundred and four studies appeared to be relevant and full-text reports were obtained and screened. Of these, 153 did not meet the eligibility criteria. Figure 1 provides a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher et al, 2010) flow chart of study selection, including reasons for exclusion. A total of 351 studies were included in this review.

Figure 1 around here

Study characteristics

Interventions and study participants

Two hundred and thirty-six studies (67%) investigated compression garments, 64 studies (18%) investigated joint supports and 42 studies (12%) investigated dynamic movement orthoses. Nine studies did not fit these intervention categories: two investigated close-fitting clothing without specifying them as compressive; three investigated heat-dissipating clothing; and four investigated orthokinetic cuffs, which are intended to alter muscle tone via differential sensations of elasticity over agonist and antagonist muscles. Over the last decade, there has been growth in the number of compression garment studies (see Figure 2) but the numbers of joint support and dynamic movement orthosis studies have remained steady, with between none and six studies published each year for joint supports and between one and four studies published each year on dynamic movement orthoses.

Two hundred and thirty-three studies (66%) investigated healthy participants. Studies on healthy participants made up 83% of the compression garment studies, 44% of the joint support studies and 7% of the dynamic movement orthosis studies (see Table 2).

Table 2 around here

Study designs

The most common study designs were cross-over trials (225 studies, 64%) and randomised controlled trials (38 studies, 11%). These more robust scientific methods were used more commonly in compression garment and joint support research than in dynamic movement orthosis research where other, less robust approaches were used, such as case descriptions and single case experimental designs (see Table 2). Cross-over studies made up 72% of the studies into compression garments but only 19% of the dynamic movement orthosis studies. Only three studies utilised qualitative methods (Miller et al, 2015; Stone, 2014, May et al, 2006).

Theming of studies according to main aim of investigation

Overall, the themes created closely matched the measures used in the studies. Measures used differed significantly between sporting and non-sporting contexts and therefore whether the study was conducted in a sporting context was used to define a number of themes.

Studies were themed as: sport performance (59 studies); sport recovery (41 studies); both sport performance and recovery (13 studies); cardiovascular and respiratory function (60 studies); posture and movement control in non-sporting contexts (62 studies); muscle activity and reflex excitability in non-sporting contexts (16 studies); impact on proprioception (23 studies); and relief or prevention of pain (30 studies). Table 3 provides an overview of the sport studies and Table 4 describes the other common study categories. Smaller categories of investigation looked at assessing pressures applied (19 studies); thermal effects (12 studies); side effects of orthoses (7

studies); development of novel designs (3 studies); acceptability and compliance (3 studies); and psychological effects (3 studies).

Table 3 around here

Table 4 around here

Studies in the sport performance and recovery themes investigated only compression garments. There is a greater range of interventions used in the other themes. For example, proprioception has been investigated in both compression garments and joint supports; posture and movement control and muscle activity have been investigated across all three main intervention groups using similar measures (see Table 4).

Sport performance and recovery studies

Sport recovery studies usually investigate wearing compression garments after exercise and commonly measure a triad of perceived muscle soreness, muscle damage markers in the circulation (such as creatine kinase and myoglobin) and the performance of an activity subsequent to a recovery period. Sport performance studies measure ability on specific sporting activities and also physiological measures of metabolism (such as oxygen uptake, lactate) and perceived exertion. Running is the most common activity investigated and lower limb garments have been more commonly tested than upper body.

Cardiovascular and respiratory function

Cardiovascular and respiratory function studies examine circulation with either ultrasound imaging or plethysmography, which measures changes in limb volume in response to occlusion of circulation. Cardiovascular function is assessed often using blood pressure monitoring, which calculates cardiac output and stroke volume from the pressure waveform. Tissue or muscle oxygenation has been investigated using near-infrared spectroscopy to determine oxygen saturation of haemoglobin in underlying tissues.

Posture and movement control in non-sporting contexts

Studies into posture and movement control (non-sport) are dominated by research with cerebral palsy but also include participants with other neurological conditions and musculoskeletal conditions. Measures include kinematics and ordinal measures of function and goal attainment.

Muscle activity and reflex excitability in non-sporting contexts

Muscle activity and reflex excitability studies include electromyography (EMG) with or without neural stimulation, such as H-reflex studies and evoked contraction studies. The H-reflex studies are used in neurological conditions to assess motor neurone excitability, believed to relate to muscle tone abnormalities. EMG studies enable objective investigation of fatigue and pain inhibition.

Proprioception

Proprioception is investigated primarily in lower limb joints, with a small number of studies assessing shoulder proprioception. The most common method of testing proprioception was joint position sense and only four proprioception studies assessed another construct, such as function or balance, alongside the assessment of proprioception.

Relief or prevention of pain

Relief and prevention of pain studies all assess perception of pain with a Visual Analogue or Numerical Rating Scale and a range of measures relevant to the underlying condition, such as stiffness, joint alignment, strength and user perceptions of ease of movement, satisfaction and support.

Comparators used in effectiveness studies

In the cross-over studies, the experimental intervention was compared to some sort of placebo or sham intervention in only 15 studies (7%), to a garment or orthosis of a different size in 31 studies (14%), to no garment/orthosis in 133 studies (59%) and to an active comparator in 39 studies (17%). In the randomised controlled trials, the experimental intervention was compared to some sort of

placebo or sham intervention in only 7 studies (18%), to a garment or orthosis of a different size in 4 studies (11%), to no garment/orthosis in 17 studies (45%) and to an active comparator in 10 studies (26%).

Pressure measurement

In the joint support and dynamic movement orthosis studies, pressure beneath the orthosis was measured in only one study (Cholewicki et al 2010a). Within the compression garment studies, pressure beneath the garment was measured in 30% of studies and the number of studies measuring pressure has changed little over the last decade (see Figure 2).

Figure 2 around here

Discussion

Main findings

This review has found that research into compression garment, joint support and dynamic movement orthosis interventions is extensive, particularly for compression garments, and there are several common measures and uses. There is limited use of placebo comparators in the effectiveness studies and few studies measure the pressure exerted by the interventions. Compression garment research is characterised by robust research designs that investigate relatively short-term effects in healthy people. Joint support studies mainly investigate short-term effects in healthy people and those with musculoskeletal conditions. Dynamic movement orthosis research is dominated by study designs that are at high risk of bias. There are very few qualitative investigations.

Discussion of main findings

Determining effectiveness of all of these interventions is complicated by difficulty blinding participants as to which intervention is experimental. For compression garments in sports, provision

of a placebo may be impossible because so many athletes are familiar with the look and feel of compression garments. Recent studies have investigated the placebo effect, by manipulating participants' expectations (Mothes et al, 2017) or by asking participants about their beliefs (Brophy-Williams et al, 2017). These approaches help to distinguish placebo effects from physiological effects and findings suggest that participants with lower confidence in their own physical abilities may respond more positively to a placebo (Mothes et al, 2017). The impact of placebo effect on outcomes can be reduced by relying less on participant self-report and using measures that are both objective and less susceptible to changes in voluntary effort. For example, Valle et al (2013) used biopsy to assess muscle damage as opposed to participant report of muscle soreness and Miyamoto and Kawakami (2014) used magnetic resonance imaging to determine muscle fatigue.

The importance of clear description of an intervention is stressed in the TIDieR guidelines (Hoffman et al, 2014). The fact that only 30% of the compression garment research measured pressure is a cause for concern and the proportion of studies where pressure is measured has not increased significantly recently despite this being strongly recommended by MacRae et al (2011). Although Beliard et al (2015) argued that pressure applied is not relevant to effectiveness, this claim is based upon a review of the effectiveness of a range of garments and is likely to be complicated by the heterogeneity of the studies included and other features of garment design, such as whether pressure profiles were graduated (higher distally) or progressive (higher proximally). A number of primary studies have demonstrated that physiological effects vary according to the pressure applied (Miyamoto et al, 2011; Coza et al, 2012; Bochman et al, 2005). In addition, a number of studies have demonstrated that pressure applied is hard to predict from sizing and varies with changes in posture and activity (Brophy-Williams et al, 2015; Hill et al, 2015; de Godoy et al 2010). Measuring pressure between the garment and the body is recommended to describe such interventions clearly.

Key gaps in primary research

Key gaps in primary research have been determined. Firstly, dynamic movement orthoses have been researched with less robust study designs. Such studies investigate the longer-term effects of the orthoses as therapeutic interventions, despite an orthotic impact never having been established. It could be argued that if no short-term orthotic effect exists, the orthoses are unlike to have a longer-term therapeutic effect. Secondly, with a few exceptions (Priego et al, 2015; Cholewicki et al, 2010b; Birmingham et al, 2008; Kirkley et al, 1999), compression garment and joint support studies rarely investigate longer-term effects. It is possible that regular, long-term use of compression garments and joint supports may be detrimental to training or may not have the predicted benefits to function that short-term studies suggest.

Compression garments and fabric orthoses are claimed to have some effect through improving sensory feedback (Watson et al, 2007; Webster et al 2017). This is researched for compression garments and joint supports but not dynamic movement orthoses. In addition, although an improvement in proprioception could theoretically improve function, this impact should not be assumed. We suggest that further studies are needed to determine if improved proprioception improves function and movement control.

Qualitative research has a role in explicating user perspectives and this enables in-depth understanding of the acceptability and feasibility of these interventions. Early research into fabric orthoses (e.g. Blair et al, 1995) collected feedback using "user comments" and unvalidated questionnaires and found very low levels of acceptability, with participants finding orthoses to be hot, uncomfortable and difficult to get on and off. More recent studies (Stone, 2014; Miller et al, 2015) have used properly designed qualitative interviews and these have enabled the issues around acceptability to be better understood. Difficulties with getting orthoses on and off still exist but acceptability appears improved, maybe due to improvements in design or the change from child to adult participants. A full understanding of acceptability will require further qualitative research.

Recommendations for future reviews

Systematic reviews have been conducted into compression garments for recovery (e.g. Brown et al, 2017; Marques-Jiminez et al, 2016); sporting performance (e.g. Born et al, 2013); joint supports for proprioception and function (e.g. Ghai et al, 2016; Duivenvoorden et al, 2015); gloves for hand arthritis (Hammond et al, 2016); and dynamic movement orthoses for cerebral palsy (Coghill and Simkiss, 2010). Systematic reviews on further topics are likely of limited value due to the heterogeneity in the field, with relatively few studies investigating the same intervention or measuring the same constructs. A narrative review, similar to that performed by MacRae et al (2011) may be useful in updating our understanding of what effects these interventions might have and their possible mechanisms. The research base has grown significantly since 2011, for example, 50% of the studies investigating the impact of compression garments on circulation have been published since 2011 and this research may alter our understanding of how compression changes venous and arterial circulation and tissue perfusion. For example, Figueiredo et al (2011) found that improving lower limb muscle recovery may be possible with compression over the muscles but that pressure on the ankle appeared unnecessary. Mosti and Partsch (2014) found that graduating pressure so that it is higher distally and lower proximally is likely to be unnecessary, even where the main aim is to improve venous circulation. An up-to-date understanding of this field may have implications for how compression garments are designed as well as guiding decision making around how garments are used in healthy people and possible clinical applications.

Strengths and limitations of review

This review followed guidelines on mapping review methods to identify and describe research on similar interventions from a range of disciplines and perspectives. This should enable researchers to identify relevant approaches from related fields and key gaps in the literature. Excluding studies on oedema and venous disorders may have limited the review as there may be studies relevant to mobility, movement and function in this wider body of literature. Additionally, some of the included

studies used ambiguous terminology to describe the interventions, such as sleeves, pantyhose and tights. The diversity of terms used to describe these interventions may have prevented some studies from being identified and may have prevented accurate identification of the actual anatomical coverage of garments. The accuracy of data extraction was checked by one reviewer (NS) who referred back to the original studies during the theming/categorising process; however, using multiple reviewers to monitor consistency of data extraction would have been more robust. Although usual for a mapping review, the lack of critique means that conclusions about the quality of this research evidence cannot be made.

Conclusion

This systematic mapping review of compression garments and fabric orthoses highlights the potential for the research on healthy people to better inform clinical research and to describe interventions accurately. Our key recommendations for future research are:

- A narrative review into the possible mechanisms of effect of compression garments and fabric orthoses.
- Further research into dynamic movement orthoses, utilising robust, mixed method designs and including investigation of short-term, orthotic effect.
- Research into the longer-term effects of compression garments and joint supports both in healthy people and in those with musculoskeletal pathologies.
- Research investigating whether dynamic movement orthoses improve proprioception and whether improved proprioception in any of these interventions improves movement control and function.
- Future studies need to fully describe interventions by including measurement of pressure beneath the orthoses or compression garments and clear description of actual anatomical coverage.

Ethical approval

Ethical approval was not required for this review.

Key points

- Compression garments and fabric orthoses are close-fitting elastic garments believed to alter movement and function.
- Compression garments, joint supports and dynamic movement orthoses have been tested for their effects in improving support, proprioception, muscle activity and posture.
- There is a need for a narrative review exploring mechanisms of action to inform future primary research.
- Further research utilising robust, mixed method designs is needed to investigate the effectiveness of dynamic movement orthoses.
- Further research is needed to explore the longer-term effects of compression garments and joint supports.
- Future research into the impact on proprioception should investigate whether improved proprioception benefits function or movement control.
- Description of interventions in published studies should include clear description of the garment or orthosis, including measurement of pressure applied.

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Table 1: Search strategy

Search	Concept	Search terms	Limited to
1	Intervention – type of material	Elastane OR spandex OR Lycra OR Elastomer* OR Theratog* OR compression OR Neoprene	All text
2	Intervention – nature of garment	Orthos* OR orthotic* OR shorts OR garment* OR splint* OR brace OR sock* OR stockings	Title and abstract
		Orthotic Devices (MEDLINE); Orthoses and Orthoses Design (CINAHL)	Subject Headings
3	Search 1 AND Search 2		

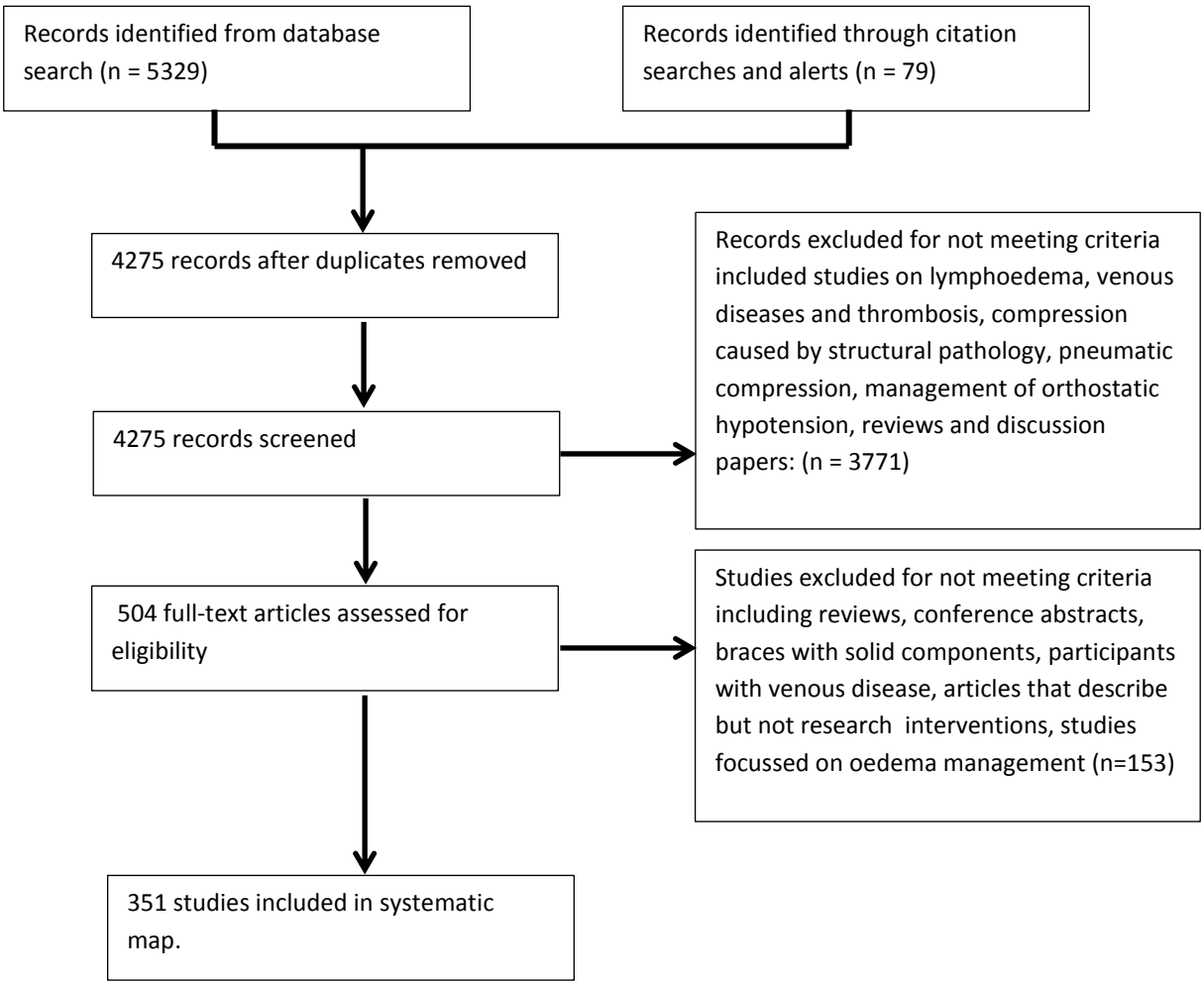

Figure 1:PRISMA flow chart of study selection process

Table 2: Overview of studies in review organised by interventions researched

	Garments used	Population	Aim of investigation	Study designs
Compression garments (236 studies)	Below-knee socks (86); waist to ankle leggings (50); thigh length stockings (24); shorts (19); calf sleeves (11); whole body garments (10); waist to foot tights (10); thigh sleeves (4); long-sleeved top (10); arm sleeves (7); gloves (6); groin to ankle leg sleeves (4); waist to mid-calf leggings (1); abdominal binding (1).	No condition or pathology (197); ACL reconstruction (1); ankle sprain (3); pregnancy or post-natal (6); leg symptoms with prolonged standing (5); arthritis (5); spinal cord injured (4); groin injury (2): stroke (1); cerebral palsy (1); runner with clotting disorder (1); Parkinson's Disease (1); developmental delay (1); sternal instability post-surgery (1); no participants (1).	Sport performance (59); cardiovascular and respiratory (59); sport recovery (41); investigating pressures applied (18); relief or prevention of pain (15); sport performance and recovery (13); thermal effects (8); muscle activity and reflex excitability (non-sport) (5); posture and movement control (non-sport) (5); proprioception (3); psychological effects (2); acceptability and compliance (3); side effects (3).	Cross-over studies (170); randomised controlled trials (26); non-randomised trials (15 - 9 used one leg in each person for intervention and one for control, 1 was a preference trial, 2 pre-post trials); matched pair trials (5); observational studies (6); measurement studies (5); developing and testing predictive models for the biomechanical effect of pressure on the body (4); single case experimental designs (2); survey (1); qualitative study (1).
Joint supports (64 studies)	Knee (14); lumbar (14); thumb (7); wrist (5); shoulder (3); finger (2); ankle (2); elbow (1); various supports in study (2).	No pathology (28); OA knee (8);OA thumb (5); knee pain or instability (7); low back pain (3); one study each on RA, hamstring injury, cerebral palsy, CMT, ankle instability, shoulder instability, joint hypermobility, finger contracture tennis elbow, club hand, wrist trauma.	Proprioception (19); posture and movement control (non-sport) (17); relief or prevention of pain (11); muscle activity and reflex excitability (non-sport) (8); side effects (4); cardiovascular and respiratory (1); investigating pressures applied (1); novel splint designs (3).	Cross-over studies (40); randomised controlled trials (7); case descriptions (10); observational (3); repeated measures (2); single case experimental design (2).
Dynamic movement orthoses (42 studies)	Whole body suit (11); shorts (8); arm sleeve (5); below knee socks (5); waist high leggings (4); various length gloves (4); shorty body suit (shoulders to thighs) (2); hip orthosis (1); trunk support (1); short sleeved shirt (1); shoulder support (2)	Cerebral palsy (15); stroke (7); no pathology (3); multiple neurological pathologies (3); scoliosis (2); brachial plexus palsy (2); DMD (2); multiple sclerosis (2); one study each on traumatic shoulder subluxation, DCD, post hip fracture, post-meningitis, RA, OA hip, spina bifida, groin injury.	Posture and movement control (non-sport) (32); relief or prevention of pain (6); muscle activity and reflex excitability (3); proprioception (1).	Case descriptions (12); pre-post trial (9); single case experimental designs (8); cross-over studies (8); randomised controlled trials (4); qualitative studies (2); notes audit (1).

Note: numbers in cells do not add up to totals because some studies contain different research designs and assess multiple garments/orthoses and populations. - Abbreviations: RA = Rheumatoid arthritis; OA = osteoarthritis; CMT = Charcot-Marie- Tooth; DCD = Developmental Coordination Disorder; DMD = Duchenne Muscular Dystrophy.

Table 3: Overview of sport performance and recovery studies

	Compression garments used	Activities	Garment worn during or after exercise
Sport performance (59 studies)	Whole body garments (6); waist high leggings (22); shorts with below-knee socks or calf sleeves (3); shorts (15); long-sleeved top (3); below knee socks (15); calf sleeves (3)	Running (30); plyometrics (10); cycling (6); resistance exercise (4); baseball and golf (1); football (3); kayaking (1); rotational lunge (1); netball (1); skiing (2); speed skating (1); throwing (1); triathlon (1); wheelchair propulsion (1)	During exercise in all studies
Sport performance and recovery (13 studies)	Below knee socks (8); waist high leggings (3); whole leg sleeve (1); calf sleeve (1)	Running (9); cycling (1); plyometrics (2); wheelchair propulsion (1); rugby (1)	During and after (7); during only (4); compared during only with during and after (2)
Sport recovery (41 studies)	Waist-high leggings (20); whole body garments (3); below knee socks (8); arm sleeves (4); shorts (2); thigh sleeves (1); calf sleeves (1); thigh length stockings (1)	Running (15); resistance exercise (8); cycling (5); plyometrics (5); rugby (3); downhill walking (2); basketball (2); hockey (1); Australian football (1); tennis (1)	After only (32); during and after (5); during only (3); compared during only and after only (1)

Note: Numbers of garments and activities do not add up to totals given because some studies tested multiple garments, activities and measures.

Table 4: Overview of main areas of research outside sport

	Garments /orthoses used	Population	Constructs commonly measured
Posture and movement control in non-sporting contexts (62 studies)	Knee support (12); whole body suit (10); waist high leggings (6); various length gloves (5); shirts or vests (5); socks (5); orthokinetic cuff (4); arm sleeve (4); lumbar support (3); thumb support (2); calf sleeves (2); one each of hip support orthosis, shoulder orthosis, finger sleeve, wrist support	Cerebral palsy (21); knee OA; (7); multiple sclerosis (4); brachial plexus palsy (2); DMD (2); no pathology (10); stroke (5); acquired brain injury (3); ACL deficiency (2); one study each included ankle sprain, hip OA, joint hypermobility, hamstring injury, finger flexion contracture, Parkinson's Disease, hip fracture, spina bifida, SCI	Walking kinematics (13); upper limb function (11); postural sway/balance (8); timed mobility (6); posture (6); functional goal attainment (6); self-perceived function (5); active range of movement (5)
Cardiovascular and respiratory function (60 studies)	Below knee socks (31); thigh length stockings (15); waist high leggings or tights (10); calf sleeves (3); one study each used whole body suit ; lumbar support, arm sleeve, abdominal compression, leg sleeve	No pathology (48) pregnancy or post-natal (6); SCI (2); one study each included occupational leg symptoms, stroke, type 2 diabetes, clotting disorder	Venous haemodynamics (flow rates and vessel structure assessed by ultrasound (20) ; venous pumping and refilling rates assessed by plethysmography (11); arterial flow rates (5); heart rate, cardiac output, stroke volume and blood pressure (8); gaseous exchange (6), tissue oxygenation (6)
Relief or prevention of pain (30 studies)	Gloves (6); thumb supports (5); below knee socks (4); knee support (3); wrist support (2); waist high leggings (2); shorts (3); one each of sternal support, shoulder support, trunk support, whole body suit and shoulder to thigh body suit	RA (6); thumb OA (5); anterior knee pain (3); occupational leg symptoms (3); scoliosis (2); ankle sprain (2); groin injury (2); shoulder subluxation (2)	All studies assess pain with Visual Analogue Scale or Numeric Rating Scale ; also function (12); other symptoms associated with each condition (8); range of movement (4); strength (3); perception of support (2); ease of movement (3); satisfaction with orthosis (3); alignment (2)
Muscle activity and reflex excitability in non-sporting contexts (16 studies)	Lumbar support (7); below knee socks (4); thigh sleeve (2); thigh length stocking (1); shorts (1); knee sleeve (1)	No pathology (10); stroke (3); sacroiliac joint pain (2); ACL reconstruction (1)	Muscle activity (EMG) (8); H-reflex (alpha motor neurone excitability) (3); evoked contraction (2); transversus abdominis thickness (1); force generated in simulated lift (1); reaction time (1); central activation ratio (ratio of voluntary to evoked contraction) (1)
Proprioception (23 studies)	Knee support (13); ankle support (3); shoulder support (3); lumbar support (2); ankle support (2); long-sleeved top (2); shorts (1); calf sleeve (1)	No pathology (18); ACL injury (2); ankle instability (1); low back pain (1) ; OA knee; shoulder instability (1)	Joint position sense (17); threshold to detection of passive movement (4); control of muscle activity (2); tracking tasks (3). 19 studies only assessed proprioception, 4 also assessed another construct

Note: numbers in cells do not add up to totals because some studies assess multiple garments/orthoses, populations and measures. Abbreviations: ACL = anterior cruciate ligament; RA = Rheumatoid arthritis; OA = osteoarthritis; CMT = Charcot-Marie- Tooth; DCD = Developmental Coordination Disorder; DMD = Duchenne Muscular Dystrophy; EMG = electromyography; SCI = spinal cord injury

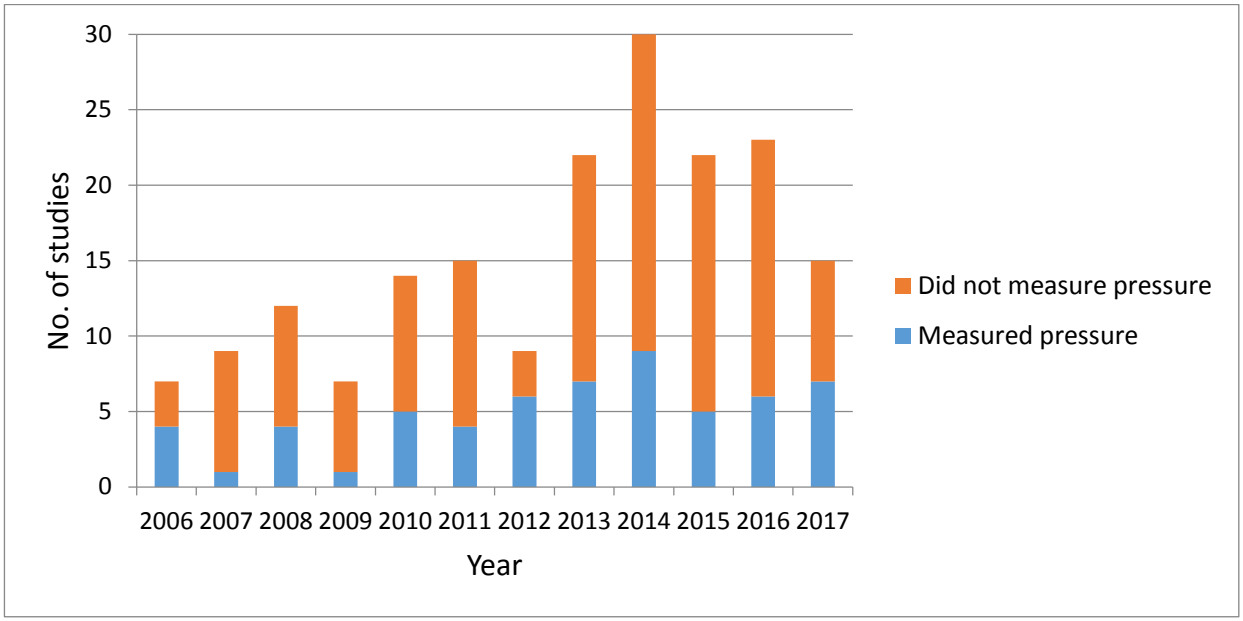

Figure 2: Proportion of compression garment studies where pressure beneath the garment was measured