Topical review

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The use of posture-correcting shirts for managing musculoskeletal pain is not supported by current evidence – a scoping review of the literature

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Abstract

Background and aims: The concept of bad posture being a dominant driver of pain is commonly held belief in the society. This may explain the significant attention supportive clothing such as posture-correcting shirts has recently gained in Scandinavia and the USA. The aim of this scoping review was to present an overview and synthesis of the available evidence for the use of posture-correcting shirts aimed at reducing pain or postural discomfort and optimising function/posture.

Methods: A systematic search was conducted for literature investigating the effect of posture-correcting shirts on musculoskeletal pain or function. PubMed, Embase, CINAHL, PEDro and the Cochrane Library were searched for relevant literature. Results of the searches were evaluated by two independent reviewers in three separate steps based on title, abstract and full text. For data synthesis, the population, intervention, comparator and outcome were extracted. The quality of the literature was evaluated using the Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies and the risk of bias was assessed using the Risk Of Bias In Non-randomized Studies – of Interventions (ROBINS-I) assessment tool or the RoB 2.0 tool for individually randomized, parallel group trials. The overall confidence in the literature was determined using the Grading of Recommendations Assessment, Development and Evaluation (GRADE).

Results: A total of 136 articles were identified and six of these were included in the review. These studies were heterogeneous with regards to aims, outcomes and methods, presenting contrasting results. The overall findings were that posture-correcting shirts change posture and subjectively have a positive effect on discomfort, energy levels and productivity. The quality of the included literature was poor to fair with only one study being of good quality. The risk of bias was serious or critical for the included studies. Overall, this resulted in very low confidence in available evidence. An important limitation of all studies was that they were conducted in pain-free individuals.

Conclusions: The contrasting findings and the low quality of current literature, questions the intended effect of posture-correcting shirts and whether the changes it creates are in fact useful for clinical practice. Moreover, the findings are contrasted by the available evidence regarding posture and pain with a particular focus on whether this management strategy may have a detrimental effect on people living with musculoskeletal pain. A major limitation to the existing literature on the effect of posture-correcting shirts is that no studies have investigated their effect in clinical populations.

Implications: Based on the available literature and the major limitation of no studies investigating clinical populations, there is no good quality evidence to support recommendation of posture-correcting shirts as a management strategy for musculoskeletal pain. Promotion of

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this product may reinforce the inaccurate and unhelpful message that poor posture leads to pain. The efficacy of such garments should be tested in clinical populations and not only in pain-free individuals, to assess whether there is any meaningful benefit of this management approach. Until then, the use of posture-correcting shirts for musculoskeletal pain is not supported by current evidence.

Keywords: posture-correcting shirt; musculoskeletal pain; health information.

1 Introduction

In society, there is a pervasive biomedical belief that spinal pain is caused and maintained by a biomedical fault [1] and that interventions that correct such fault would lead to symptom resolution. One commonly held belief is the idea of posture being a dominant driver of pain [2], and this is commonly reinforced by many healthcare professionals [3]. In contrast, current evidence, ranging from adolescents to adult populations [4–7] does not support these beliefs. In fact, there is a growing body of evidence demonstrating only weak associations between posture and musculoskeletal pain conditions such as low back pain (LBP) [8, 9]. Musculoskeletal pain is multidimensional in nature [10–13] where a nociceptive stimuli from somatic structures can only explain part of the pain experience which can be described as a response to a sense of threat to the body [11–13]. In spite of this knowledge, a biomedical focus is common, in particular postural advice [3, 14] and the use of passive gadgets to correct posture, such as the use of posture-correcting shirts for the self-management of musculoskeletal pain has increased in popularity, particularly in Scandinavia and the USA. Professionals recommending posture-correcting shirts claim that the shirts facilitate optimal posture and thereby create favourable loading of the spine and the surrounding peripheral joints. Such claims contrast the available evidence.

The translation of health-related information to the public through the media can influence population-based beliefs and behaviours relating to LBP [15]. For example, a mass media campaign in Australia induced positive changes in both community and physicians' beliefs about back pain, as well as a decline in number of LBP-related worker's compensation claims [16]. However, misconceptions about spinal health and pain continue to exist; in part because people often encounter less-evidence based information on social media and other platforms. Recent calls for mass media campaigns targeting LBP misconceptions for instance, compete with existing marketing campaigns that promote low value interventions [17]. From a patient perspective, solutions that are simple, easy to understand, aligned with traditional biomedical views, and that require a minimal effort, are understandably appealing. Therefore, it is critical that public claims relating to musculoskeletal pain are evidence-based, clear, and in the public's best interest. The apparent mismatch between the alleged effect of posture correcting clothing and the available evidence warrants an investigation of whether there is any basis for such claims.

The purpose of this scoping review is to present an overview of the available evidence for the use of posture-correcting shirts to reduce pain, optimise function and/or correct posture. The results from the available literature will be synthesized and discussed. Particular focus will be on the relationship between posture and pain and the potential implications of recommending the use of posture-correcting clothing for managing musculoskeletal pain and improving function.

2 Methods

2.1 Literature search

Initially, a free-text search was used online to identify synonyms that could later on be used in the search matrix. The final search strategy was then designed with the assistance of an experienced librarian. The literature search was conducted in the period April – May 2018 on PubMed, Embase, CINAHL, PEDro and the Cochrane Library to identify relevant articles. This consisted of a comprehensive strategy where indexed terms were combined with free text with four main components: (1) Posture shirt, (2) Alignment shirt (3) Dynamic elastic garment and (4) Posture correcting. In the following segments, these will collectively be referred to as posture-correcting shirts. The results and the full search strategy are available in Table 1 but the protocol was not published prior to commencing this work. In an effort to be as inclusive as possible, the search included gray literature through the following sources: conference proceedings, websites from Intelliskin and Alignmed and by investigating the reference list of all included studies. Two independent reviewers (TR and SIM) conducted the search and screening of eligible articles. The reviewers dealt with any disagreement or uncertainty by discussion until consensus

Table 1: Overview of the search strategy and MESH terms used for identifying relevant research articles for this scoping review.

Number	Search terms	Results	Database					
			PubMed	Embase	CINAHL	PEDro	Cochrane	Total
1	"Posture shirt" OR "postural shirt" OR "posture shirts" OR "postural shirts" OR "postural shirt" OR "alignment shirt" OR (posture AND shirt)	Total hits	29	48	9	2	5	91
		Included abstracts	4	3	4	0	0	14
		Included articles	4	3	4	0	0	14
2	"Dynamic elastic garment" OR "Dynamic elastic garments" OR ("Dynamic" AND "elastic" AND "garment')	Total hits	17	8	0	0	0	25
		Included abstracts	1	1	0	0	0	2
		Included articles	1	1	0	0	0	2
3	((((("compression garments" OR "compression garment" OR ("compression" AND "garments") OR ("compression" AND "garment"))) AND "Clothing" [Mesh])) AND shirt	Total hits	8	5	0	1	1	15
		Included abstracts	4	4	0	1	1	10
		Included articles	1	1	0	0	0	2
4	"Posture-cueing shirt" OR "Posture-cueing AND shirt"	Total hits	2	0	1	0	0	3
		Included abstracts	1	0	1	0	0	2
		Included articles	1	0	1	0	0	2

The table shows the total number of items found within each database (number of hits) and the relevant abstracts and articles that were included after a screening process.

was reached. In case consensus could not be reached, the third reviewer (SWC) had the final deciding vote.

2.2 Eligibility criteria

The inclusion criteria were as follows:

1. Published in English, Danish, Norwegian, Swedish or German
2. The study described that the shirt was intended to correct posture
3. Study described that the shirt was intended to prevent, or manage or improve musculoskeletal pain
4. Study described that the shirt was intended to prevent, or manage, or improve musculoskeletal function

The variables of particular interest were musculoskeletal pain and function, irrespective of whether the study population was with or without pain at inclusion. Therefore, we searched for studies that investigated the effect of posture-correcting shirts in both clinical and experimental settings. Acknowledging that no similar reviews have been performed, studies using both validated and non-validated assessment methods for these outcomes were included in the review. This included subjective measures of pain/discomfort and function. Excluded studies were those in which the effect of a posture shirt was not measured on a musculoskeletal component. Non-peer reviewed studies were not included in the final overview.

2.3 Screening process

The screening process was conducted independently by two group members (TR and SIM). The first step consisted of evaluating the titles and removing those studies where eligibility could be determined. In the second step, the reviewers independently read the abstracts and removed duplicates and studies that were not eligible. The remaining studies were included in the final synthesis. In case of any disagreement between the two reviewers, a third group member (SWC) took the final decision regarding the eligibility of a study.

2.4 Study quality

The Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies [18] was used to determine the quality of the included studies. Two independent reviewers (TR and SIM) independently evaluated the quality of the included studies and afterwards compared their findings. In case of a disagreement they could not resolve, the third reviewer (SWC) had the final vote.

2.5 Risk of bias

Based on study design, the risk of bias was assessed by two independent reviewers (TR and SIM), using the Risk Of Bias In Non-randomized Studies – of Interventions (ROBINS-I) assessment tool [19] or the RoB 2.0 tool for individually randomized, parallel group trials [20]. Any differences in their assessment were resolved by the third reviewer (SWC).

2.6 Data synthesis and overall confidence in the available literature

The population, intervention, comparator and outcome (PICO) were extracted and plotted into a table by the primary author (TSP) to enable a synthesis of the main findings from the included studies. The overall confidence in the evidence supporting the use of posture-correcting shirts of improving pain and function was determined by using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) [21]. Here, two independent reviewers (TSP and SIM) assessed the included studies; and any disagreement was solved by a third group member (SWC).

3 Results

3.1 Included studies from the screening process

In total, 136 articles were found of which 111 were excluded during the first step of the screening process based on the title. After removing articles based on abstract and duplicates, six scientific articles that could be included in the overview remained. The flowchart as suggested by PRISMA, showing the screening process can be seen in Fig. 1. An overview of the included studies can be seen in Table 2. All of the included studies were conducted on pain-free subjects only and were heterogeneous in terms of how outcomes for pain and function were measured.

3.2 Study quality and risk of bias

The quality of the included studies ranged from poor [22, 23], to fair [24–26] to good [27] (Table 3). The risk of bias was considered serious [23–26], critical [22] or with some concerns [27] (Table 4).

3.3 Data synthesis and overall confidence in the available literature

The outcomes of interest, pain and function were measured in a heterogeneous manner. Pain was not measured in any of the included studies but, discomfort was measured in one study [22]. Function was measured as internal rotation speed of the shoulder [24], handgrip strength and postural fatigue [23], activity of axioscapular muscles [27] and position of head, shoulder or scapula [23, 25, 26]. For pain, the evidence was downgraded based on study design (–1), risk of bias (–2), indirectness (–1) and imprecision (–2). For function, the evidence was downgraded for study design (–1), risk of bias (–2), inconsistency (–1), indirectness (–2)

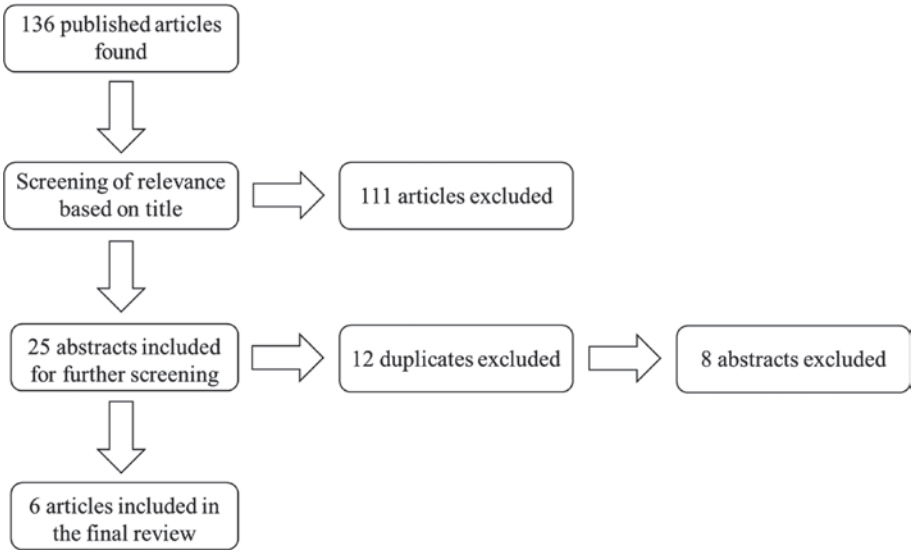


Fig. 1: Flow diagram illustrating the process of identifying the available literature.

Table 2: An overview of the included studies demonstrating the population included, the Intervention, what the intervention was compared with and what outcomes were used in the study.

Author	Population	Intervention	Comparator	Outcome	Results
Zappala et al. [24]	Healthy males and females ($n = 9$)	A postural-correcting t-shirt (Single session, single tennis serve)	A standard tennis t-shirt (non-randomized crossover trial)	– The speed on internal rotation of the shoulder during a tennis serve measured with three dimensional kinematic analysis	Higher internal rotation speed using a postural correcting t-shirt ($p < 0.09$)[a]
Decker et al. [23]	Healthy males and females ($n = 96$)	A dynamic elastic posture t-shirt (4-week cohort study)	None	– Disability measured with the Disabilities of the Arm, Shoulder and Hand (DASH) outcome questionnaire – Posture measured with the double square method and static digital photo at: – Forward shoulder – Head position – Thoracic kyphosis – Handgrip strength measured with a hand-held dynamometer – Lung capacity measured with a spirometer – Postural- and muscular fatigue measured with a visual analogue scale	An improvement forward shoulder and head posture, thoracic kyphosis and grip strength. Reduced postural and muscular fatigue and increased energy levels and productivity ($p < 0.05$)
Manor et al. [25]	Healthy males and females ($n = 24$)	A corrective posture shirt	A sham shirt	– A forward shoulder and head angle was measured with a photographic posture assessment	A decrease in forward shoulder angle using the sham shirt. No effect of corrective posture shirt
Cipriani et al. [22]	Healthy male and female cyclists ($n = 20$)	A posture correcting shirt	None	During a ride: – Self-perceived effect on: – Posture – Fatigue, – Discomfort – Breathing During recovery: – Self-perceived effect on: – Posture – Discomfort – Breathing – Feeling of tension – Recovery after ride All measurements were done with a custom-made questionnaire ranging between –3 (substantial negative influence) to +3 (substantial positive influence)	Self-perceived positive experience during ride but a greater positive experience during recovery

Table 2 (continued)

Author	Population	Intervention	Comparator	Outcome	Results
Cole et al. [27]	Healthy male and female overhead athletes ($n = 38$)	A compression shirt with strap tension	A compression shirt without strap tension	– Head and shoulder angles were measured with lateral-view digital photographs. – Normalized EMG measures of upper-, medial and lower trapezius (upper, medial and lower) and serratus anterior activity during isometric contractions during four exercises and two glenohumeral motions	Decreased forward shoulder angle compared with control shirt Normlized EMG: – Flexion: Increased activity for LT with and without strap tension – Extension: Decreased UT and MT activity with and without strap tension – Y´s: Increased LT activity with and without strap tension
Gascon et al. [26]	Healthy active females ($n = 40$)	Posture correcting compression garment	A generic performance garment	– A comparison of scapular positioning using the posture correcting garment or a generic garment as measured with an electromagnetic tracking system	The posture correcting garment caused an increased retraction and posterior tilt of the scapula ($p < 0.05$)

The results from each respective study are demonstrated in the column to the far right.
[a]Authors set the level of significance to $p < 0.1$ on the premise that it was an exploratory study.

and imprecision (–1) (Table 5). Therefore, there is very low overall confidence that posture-correcting shirts are effective for reducing pain and improving function.

4 Discussion

This scoping review is the first overview of the available evidence on whether posture-correcting shirts can reduce musculoskeletal pain and improve function. A systematic literature search resulted in the inclusion of six studies of varying quality (from poor to good) and overall serious risk of bias. In general, the included studies demonstrated results in favor of the posture-correcting shirts for improving pain and function. However, in considering the study designs, the risk of bias as well as the inconsistency, inderectness and imprecision of the outome measures the overall confidence in these findings was very low, meaning that the true effect in clinical populations is potentally very different from the reported effects. These findings and their implications for clinical practice are discussed in the following sections with focus on current evidence of the relationship between spinal posture and pain. Lastly, based on the findings of this review, we discuss whether reccomendations for use of posture-correcting shirts could/should be made.

4.1 What do posture-correcting shirts do and can they positively influence pain or function?

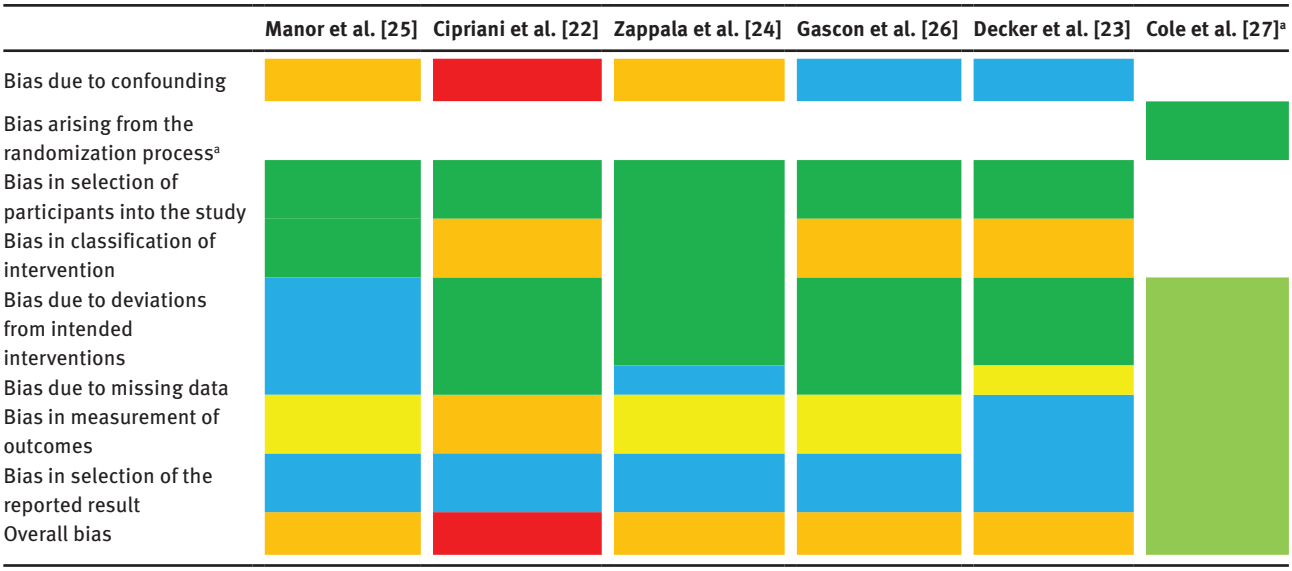
The current review indicates that there is no good quality evidence to support the use of posture-correcting shirts to influence pain or function. The key reason for that is the lack of evidence from studies in people with pain; all the included studies were performed on healthy, asymptomatic subjects (Table 3). Thus, there exists no data in the included literature which suggests a meaningful effect on pain in any cohort with a painful condition.

The minimal requirements for any chosen treatment for any given musculoskeletal pain problem are that they are targeted against the suggested underlying driver of the pain condition [28]. A common theme in the studies included here, is that the posture-correcting shirts successfully changed aspects of upright posture as seen

Table 3: Quality assessment of the included articles using the Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies.

Quality assessment tool for observational cohort and cross-sectional studies	Included studies											
	Zappala et al. [24]		Decker et al. [23]		Manor et al. [25]		Cipriani et al. [22]		Cole et al. [27]		Gascon et al. [26]	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
1. Was the research question or objective in this paper clearly stated?	X		X		X		X		X		X	
2. Was the study population clearly specified and defined?	X			X	X		X		X			X
3. Was the participation rate of eligible persons at least 50%?	X		X			X	Cannot determine			X	Cannot determine	
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	X		Cannot determine		X		X		X		Cannot determine	
5. Was a sample size justification, power description, or variance and effect estimates provided?		X		X		X		X	X			X
6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?	X		X		X			X	X		X	
7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?	Cannot determine		X		Cannot determine		X		Cannot determine		Cannot determine	
8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g. categories of exposure, or exposure measured as continuous variable)?	Not applicable		Not applicable		Not applicable		X		Not applicable		Not applicable	
9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	X		X		X			X	X		X	
10. Was the exposure(s) assessed more than once over time?		X		X	X			X		X		X
11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	X		X		X			X	X		X	
12. Were the outcome assessors blinded to the exposure status of participants?		X		X		X	X		X			X
13. Was loss to follow-up after baseline 20% or less?	X			X	X		X		X		X	
14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?		X		X	X			X	X		Cannot determine	
Quality	Fair		Poor		Fair		Poor		Good		Fair	

Table 4: Risk of Bias assessment of the included studies.



Low risk ; Some concerns; Moderate risk; Serious risk; Critical; No information; Not applicable. Depending on the study design, the assessment was performed using the Risk Of Bias In Non-randomized Studies – of Interventions (ROBINS-I) assessment tool or the RoB 2.0 tool for individually randomized, parallel group trials. Only one study (Cole et al.) was assessed with RoB 2.0. The specific question from the questionnaire is indicated by[a]. NI = no information; N/A = not applicable.

Table 5: The Grading of Recommendations Assessment, Development and Evaluation (GRADE) for pain and function in the included studies.

Outcome measure	Number of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Confidence
Pain	1	↓[a]	↓↓[b]		↓[c]	↓↓[d]	Very low
Function	6	↓[e]	↓↓[f]	↓[g]	↓↓[h]	↓[i]	Very low

[a]Only one study [22] assessed a pain-related outcome. This study had an observational design and did not include a control group.
[b]Only one study [22] assessed the effect of a posture-correcting shirt on a pain-related variable (discomfort). The study did not use a control group and subjects and assessors were not blinded to their condition. For more detailed information regarding the risk of bias, see appendix 2.
[c]The only study [22] assessing a pain-related outcome did not ask for a pain reduction. Additionally, the study was conducted in a pain-free population where the effect was measured on a training-induced discomfort.
[d]The only study assessing a pain-related variable (discomfort, [22]) used a subjective experience of reduction to measure the effect. The questionnaire used has not been validated so the results cannot be considered reliable for the measure of pain.
[e]Only one of the studies [27] had subjects randomly allocated into groups. The remaining studies were observational studies with [24–26] or without [23] a control condition.
[f]In total, the included studies and their design was expected to pose a very serious risk of bias. For more detailed information regarding the risk of bias in each study, see appendix 2.
[g]For function (posture and/or muscle activity) the majority of the studies assessing head and/or shoulder posture showed a favorable outcome from wearing a posture-correcting shirt. One study [25] showed no effect of the posture-correcting shirt but a positive effect of the sham shirt. All participants in all studies were healthy and asymptomatic and therefore was the study population homogenous. Overall, the groups were similar enough to compare the results and in 5 of the studies the dosage was similar. Only [23] had a 4 week duration whereas the remaining studies investigated the immediate effect of the shirt.
[h]The majority of studies assessed the immediate effect of posture-correcting shirts on function where only one [23] followed the cohort longitudinally. Moreover, all of the studies were done on healthy individuals and therefore it is not possible to determine whether posture-correcting shirts can improve function in a clinically meaningful way.
[i]The studies are heterogeneous with regards to how function is measured.

on reduced forward shoulder and head postures and [23, 27], reduced thoracic kyphosis [23] and increased scapular retraction and posterior tilt [26]. However, the only available studies that fulfilled the inclusion criteria were studies in which only healthy, asymptomatic subjects participated and, these studies were of low quality (Table 3). Additionally, the overall changes observed in the included studies collectively indicate that the changes

are small, and it is very unclear whether the reported changes are reflecting a true, lasting change or simply an immediate response for doing something different. This is supported by a lack of experimental control groups in the included studies. Importantly, it is unclear whether the observed changes have any lasting clinical value. Other examples are the use of passive back support in form of braces [29], or cutaneous feedback in form of kinesiotape [30], that only provide a small, short lasting effect on pain. Moreover, there are studies that have suggested a relationship between posture and musculoskeletal pain conditions [31–33] where a posture-correcting strategy may be indicated as part of the intervention. This has however been negated in larger studies in which there was no identified relationship between spinal curvature and pain (headache, neck- or back pain) in adolescents [34], adults [5, 6] or an elderly population [7]. Passive coping strategies are known to predict greater risk of sick leave in people with back pain [35], where advice such as correcting posture for pain relief with an external aid such as a posture-correcting shirt may reinforce patient perceptions of vulnerability and have negative effects on function [14]. Therefore, whatever effect posture correction may have in the short term, they may not be helpful in the long term.

Current evidence indicates that the relationship between spinal curvature is coincidental, i.e. not necessarily indicative of the cause of pain [5] and that any associations between spinal curvature and pain are not to be regarded as causal [36]. Correcting posture to manage musculoskeletal pain may therefore seem as a narrow approach when considering the synergistic effects and associations for chronic spinal pain and psychological distress which are evident in people seeking care within the healthcare sector [37]. Moreover, in the context of posture and pain, studies looking at the relationship between posture and pain, often indicate that posture is more strongly associated with emotional factors than pain itself [34, 38, 39]. Likewise, pessimistic or unhelpful views regarding back pain are highly associated with high pain intensity and high disability levels [40].

4.2 What information is relevant for those considering to buy posture-correcting shirts?

Considering there are no studies investigating the use of posture-correcting shirts in people with musculoskeletal pain, the low quality and high risk of bias of the included studies, current evidence does not support the use of posture-correcting shirts for managing musculoskeletal pain.

Maintaining "good" posture is a commonly reported "rule" (*"sit up straight" or "don't slouch"*) advised by healthcare professionals. It is therefore understandable that patients adhere to clinical advice regarding postural correction, and in doing so, it provides them with a feeling that they are doing something for their pain [14]. As a self-management strategy, it is easy to understand the arguments for encouraging people to invest in posture-correcting shirts. They are relatively inexpesive (compared to paying for treatment within the primary sector), they correct posture [23, 26, 27] and they create a subjective experience of improved posture and reduced discomfort [22], increased energy levels and productivity [23] (Table 1). Nevertheless, promoting a strategy aimed at maintaining a certain posture may seem contradictory considering that clinical populations such as patients with back pain demonstrate a lack of movement variability [41, 42], spend a greater part of their working day in the same position [43] and have higher levels of trunk muscle activity when compared with controls [44, 45]. In other words, the argument for moving less or maintaining the same posture is difficult to support when reduced movement seems to be a feature for many back pain patients.

Contemporary evidence strongly supports the notion that pain is an individual experience that is influenced by factors from multiple dimensions [46] suggesting that a uni-dimensional solution such as a posture-correcting shirt may seem like an oversimplification of a problem such as musculoskeletal pain. Individual pain-related dysfunction is influenced by the person's perception of fragility and beliefs regarding their pain condition [47]. This relates to the explanatory and prognostic labels people attach to the pain experience: the potential causes and consequences, the level of control people feel they have over their pain and how long they expect the pain to last [48]. For most people, maintaining a good posture is commonly understood to be an important strategy to protect their back [1]. However, defining good posture is difficult as there is a lack of consensus on which posture is optimal [49]. Additionally, asymptomatic individuals demonstrate great variability in how they align their body [50]; a trait that also seems to change as we get older [51]. This inevitably questions the overall implicit messaging that an optimal posture exists, and the explicit message that a posture correcting garment may facilitate maintaining this optimum position.

Healthcare professionals are in a key position to facilitate a process towards recovery and have the advantage of being trained in anatomy and understanding the function of the human body. Here, it is important to be mindful that anatomical labels, such as suggesting muscular imbalance or reduced tissue tolerance to load may negatively affect the person's perception of their problem, instilling fear and disability behaviours [47, 52, 53]. In other words, clinicians and others who provide advice based on pathoanatomical models must consider that their words and explanations may have unintended, negative meanings for the patient [54].

Key aspects of a person's rehabilitation are to facilitate an understanding of their problem and provide strategies that promote independence. These, can be achieved by establishing a strong therapeutic alliance, facilitating the patient's development of body awareness and helping the patient to gain control over the pain condition [55]. The intended purpose of a posture-correcting shirt seems to signal the opposite as pain is attributed to a *"postural fault"* and the user becomes passively dependent on the shirt to *"correct"* this fault.

5 Conclusion

The purpose of this scoping review was to create an overview of the available evidence for using posture-correcting shirts for improving musculoskeletal pain and function. Surprisingly, all the available studies only included healthy, pain-free subjects. The included studies were of varying quality and had a serious risk of bias. There is very low overall confidence that posture-correcting shirts are effective for reducing pain and improving function. Thus, current evidence does not support the use of posture-correcting shirts in the management of musculoskeletal pain. We contend that public promotion of reductionist approaches such as posture-correcting shirts is not reflective of the current understanding of posture and pain, and should not be encouraged.

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References

[1] Darlow B, Perry M, Stanley J, Mathieson F, Melloh M, Baxter GD, Dowell A. Cross-sectional survey of attitudes and beliefs about back pain in New Zealand. BMJ Open 2014;4:e004725.

[2] O'Sullivan K, O'Keeffe M, O'Sullivan L, O'Sullivan P, Dankaerts W. Perceptions of sitting posture among members of the community, both with and without non-specific chronic low back pain. Man Ther 2013;18:551–6.

[3] Setchell J, Costa N, Ferreira M, Makovey J, Nielsen M, Hodges PW. Individuals' explanations for their persistent or recurrent low back pain: a cross-sectional survey. BMC Musculoskeletal Disorders 2017;18:466.

[4] O'Sullivan P, Smith A, Beales D, Straker L. Understanding adolescent low back pain from a multidimensional perspective: implications for management. J Orthop Sports Phys Ther 2017;47:741–51.

[5] Grob D, Frauenfelder H, Mannion AF. The association between cervical spine curvature and neck pain. European Spine Journal 2007;16:669–78.

[6] Murrie VL, Dixon AK, Hollingworth W, Wilson H, Doyle TA. Lumbar lordosis: study of patients with and without low back pain. Clinical anatomy (New York, NY) 2003;16:144–7.

[7] Ettinger B, Black DM, Palermo L, Nevitt MC, Melnikoff S, Cummings SR. Kyphosis in older women and its relation to back pain, disability and osteopenia: the study of osteoporotic fractures. Osteoporosis international: a journal established as result of cooperation between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA 1994;4:55–60.

[8] O'Sullivan PB, Smith AJ, Beales DJ, Straker LM. Association of biopsychosocial factors with degree of slump in sitting posture and self-report of back pain in adolescents: a cross-sectional study. Phys Ther 2011;91:470–83.

[9] Smith A, Beales D, O'Sullivan P, Bear N, Straker L. Low back pain with impact at 17 years of age is predicted by early adolescent risk factors from multiple domains: analysis of the western australian pregnancy cohort (raine) study. J Orthop Sports Phys Ther 2017;47:752–62.

[10] Loeser JD, Melzack R. Pain: an overview. The Lancet 1999;353:1607–9.

[11] Moseley GL. Reconceptualising pain according to modern pain science. Physical Therapy Reviews 2007;12:169–78.

[12] Moseley GL, Butler DS. Fifteen years of explaining pain: the past, present, and future. J Pain 2015;16:807–13.

[13] Zusman M. Forebrain-mediated sensitization of central pain pathways: "non-specific" pain and a new image for MT. Man Ther 2002;7:80–8.

[14] Darlow B, Dowell A, Baxter GD, Mathieson F, Perry M, Dean S. The enduring impact of what clinicians say to people with low back pain. Ann Fam Med 2013;11:527–34.

[15] Suman A, Bostick GP, Schopflocher D, Russell AS, Ferrari R, Battie MC, Hu R, Buchbinder R, Gross DP. Long-term evaluation of a Canadian back pain mass media campaign. Eur Spine J 2017;26:2467–74.

[16] Buchbinder R, Jolley D, Wyatt M. 2001 Volvo Award Winner in Clinical Studies: effects of a media campaign on back pain beliefs and its potential influence on management of low back pain in general practice. Spine (Phila Pa 1976) 2001;26:2535–42.

[17] O'Keeffe M, Maher CG, Stanton TR, O'Connell NE, Deshpande S, Gross DP, O'Sullivan K. Mass media campaigns are needed to counter misconceptions about back pain and promote higher value care. Br J Sports Med 2018:bjsports-2018-099691. [Epub ahead of print]
[18] NIH National Heart LaBIN. Study quality assessment tools: quality assessment tool for observational cohort and cross-sectional studies: U.S. Department of Health & Human Services. Available at: https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools. Accessed: 29 Nov 2018.
[19] Sterne JA, Hernan MA, Reeves BC, Savovic J, Berkman ND, Viswanathan M, Henry D, Altman DG, Ansari MT, Boutron I, Carpenter JR, Chan AW, Churchill R, Deeks JJ, Hrobjartsson A, Kirkham J, Juni P, Loke YK, Pigott TD, Ramsay CR, et al. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. Br Med J 2016;355:i4919.
[20] Higgins JPT, Sterne JAC, Savović J, Page MJ, Hróbjartsson A, Boutron I, Reeves B, Eldridge S. A revised tool for assessing risk of bias in randomized trials. Cochrane Database Syst Rev 2016;10:29–31.
[21] Guyatt G. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. Br Med J 2008;336:924–6.
[22] Cipriani DJ, Yu TS, Lyssanova O. Perceived influence of a compression, posture-cueing shirt on cyclists' ride experience and post-ride recovery. J Chiropr Med 2014;13:21–7.
[23] Decker M, Gomas KA, Narvy SJ, Vangsness CT. The influence of a dynamic elastic garment on musculoskeletal and respiratory wellness in computer users. Int J Occup Saf Ergon 2016;22:550–6.
[24] Zappala J, Orrego C, Boe E, Fechner H, Salminen D, Cipriani DJ. Influence of posture-cuing shirt on tennis serve kinematics in division III tennis players. J Chiropr Med 2017;16:49–53.
[25] Manor J, Hibberd E, Petschauer M, Myers J. Acute effects of posture shirts on rounded-shoulder and forward-head posture in college students. J Sport Rehabil 2016;25:309–14.
[26] Gascon SS, Gilmer GG, Hanks MM, Washington JK, Oliver GD. Biomechanical influences of a postural compression garment on scapular positioning. Int J Sports Phys Ther 2018;13:700–6.
[27] Cole AK, McGrath ML, Harrington SE, Padua DA, Rucinski TJ, Prentice WE. Scapular bracing and alteration of posture and muscle activity in overhead athletes with poor posture. J Athl Train 2013;48:12–24.
[28] Slater H, Briggs AM. Models of Care for musculoskeletal pain conditions: driving change to improve outcomes. Pain Manag 2017;7:351–7.
[29] van Duijvenbode I, Jellema P, van Poppel M, van Tulder MW. Lumbar supports for prevention and treatment of low back pain. Cochrane Database Syst Rev 2008;16:1–36.
[30] Chang NJ, Chou W, Hsiao PC, Chang WD, Lo YM. Acute effects of Kinesio taping on pain, disability and back extensor muscle endurance in patients with low back pain caused by magnetic resonance imaging-confirmed lumbar disc degeneration. J Back Musculoskelet Rehabil 2018;31:85–93.
[31] Szeto GP, Straker L, Raine S. A field comparison of neck and shoulder postures in symptomatic and asymptomatic office workers. Appl Ergon 2002;33:75–84.
[32] Kim E-K, Kim JS. Correlation between rounded shoulder posture, neck disability indices, and degree of forward head posture. J Phys Ther Sci 2016;28:2929–32.
[33] Im B, Kim Y, Chung Y, Hwang S. Effects of scapular stabilization exercise on neck posture and muscle activation in individuals with neck pain and forward head posture. J Phys Ther Sci 2016;28:951–5.
[34] Richards KV, Beales DJ, Smith AJ, O'Sullivan PB, Straker LM. Neck posture clusters and their association with biopsychosocial factors and neck pain in Australian adolescents. Phys Ther 2016;96:1576–87.
[35] Dawson AP, Schluter PJ, Hodges PW, Stewart S, Turner C. Fear of movement, passive coping, manual handling, and severe or radiating pain increase the likelihood of sick leave due to low back pain. Pain 2011;152:1517–24.
[36] Christensen ST, Hartvigsen J. Spinal curves and health: a systematic critical review of the epidemiological literature dealing with associations between sagittal spinal curves and health. J Manipulative Physiol Ther 2008;31:690–714.
[37] Hoffmann K, Peersman W, George A, Dorner TE. Associations and synergistic effects for psychological distress and chronic back pain on the utilization of different levels of ambulatory health care. A Cross-Sectional Study from Austria. PLoS One 2015;10:e0134136.
[38] Diepenmaat AC, van der Wal MF, de Vet HC, Hirasing RA. Neck/shoulder, low back, and arm pain in relation to computer use, physical activity, stress, and depression among Dutch adolescents. Pediatrics 2006;117:412–6.
[39] O'Sullivan P, Beales D, Jensen L, Murray K, Myers T. Characteristics of chronic non-specific musculoskeletal pain in children and adolescents attending a rheumatology outpatients clinic: a cross-sectional study. Pediatr Rheumatol Online J 2011;9:3.
[40] Urquhart DM, Bell RJ, Cicuttini FM, Cui J, Forbes A, Davis SR. Negative beliefs about low back pain are associated with high pain intensity and high level disability in community-based women. BMC Musculoskeletal Disorders 2008;9:148.
[41] Falla D, Gizzi L, Tschapek M, Erlenwein J, Petzke F. Reduced task-induced variations in the distribution of activity across back muscle regions in individuals with low back pain. Pain 2014;155:944–53.
[42] Falla D, Gizzi L, Parsa H, Dieterich A, Petzke F. People with chronic neck pain walk with a stiffer spine. J Orthop Sports Phys Ther 2017;47:268–77.
[43] Wong KCH, Lee RYW, Yeung SS. The association between back pain and trunk posture of workers in a special school for the severe handicaps. BMC Musculoskeletal Disorders 2009;10:43.
[44] Lima M, Ferreira AS, Reis FJJ, Paes V, Meziat-Filho N. Chronic low back pain and back muscle activity during functional tasks. Gait Posture 2018;61:250–6.
[45] Sheeran L, Sparkes V, Caterson B, Busse-Morris M, van Deursen R. Spinal position sense and trunk muscle activity during sitting and standing in nonspecific chronic low back pain: classification analysis. Spine (Phila Pa 1976) 2012;37:E486–95.
[46] IASP. Part III: pain terms, a current list with definitions and notes on usage. In: Merskey H, Bogduk N, editors. Seattle: IASP Press; 1994.
[47] Darlow B. Beliefs about back pain: the confluence of client, clinician and community. Int J Osteopath Med 2016;20:53–61.
[48] Bunzli S, Smith A, Schutze R, Lin I, O'Sullivan P. Making sense of low back pain and pain-related fear. J Orthop Sports Phys Ther 2017;47:628–36.

[49] O'Sullivan K, O'Sullivan P, O'Sullivan L, Dankaerts W. What do physiotherapists consider to be the best sitting spinal posture? Man Ther 2012;17:432–7.
[50] D'Amico M, Kinel E, Roncoletta P. Normative 3D opto-electronic stereo-photogrammetric posture and spine morphology data in young healthy adult population. PLoS One 2017;12:e0179619.
[51] Nemmers TM, Miller JW, Hartman MD. Variability of the forward head posture in healthy community-dwelling older women. J Geriatr Phys Ther (2001) 2009;32:10–4.
[52] Bunzli S, Smith A, Schutze R, O'Sullivan P. Beliefs underlying pain-related fear and how they evolve: a qualitative investigation in people with chronic back pain and high pain-related fear. BMJ Open 2015;5:e008847.
[53] Sloan TJ, Walsh DA. Explanatory and diagnostic labels and perceived prognosis in chronic low back pain. Spine (Phila Pa 1976) 2010;35:E1120–5.
[54] Barker KL, Reid M, Minns Lowe CJ. Divided by a lack of common language? A qualitative study exploring the use of language by health professionals treating back pain. BMC Musculoskelet Disord 2009;10:123.
[55] Bunzli S, McEvoy S, Dankaerts W, O'Sullivan P, O'Sullivan K. Patient perspectives on participation in cognitive functional therapy for chronic low back pain. Phys Ther 2016;96:1397–407.