Developing a Guideline Framework for School-Based Interventions to Improve Spinal Health of Children and Adolescents in South Africa

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DECLARATION

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ABSTRACT

BACKGROUND: Spinal pain prevalence in children and adolescents is high, increases with age and may lead to spinal pain in adulthood. Potential predisposing factors for spinal pain in children and adolescents are the usage of schoolbags; posture; sitting duration; psychosocial factors; age; gender and school furniture.

PURPOSE: 1) To determine the effectiveness of school-based interventions in promoting spinal health in children and adolescents; 2) to present a schematic presentation of the effective interventions as part of development of an evidence-based framework.

METHODS: This study had two phases: 1) conducting a systematic review on the effectiveness of school-based interventions to promote spinal health in children and adolescents, 2) developing a schematic presentation of the evidence-based framework depicting the effective school-based interventions. Two comprehensive search strategies for primary research (strategy A) and grey literature (strategy B) respectively, were performed. School-based interventions which aims were to prevent poor spinal health and/or improve spinal health in school children and adolescents were considered. Spinal health outcomes included levels of pain or discomfort limited to the spinal area and other measurable components which is a direct result of the spinal pain/discomfort and which affects the individual's optimal experience of a sense of well-being.

RESULTS: Search strategy A yielded 24 eligible articles and search strategy B, six documents of grey literature. Four main themes of intervention were identified i.e. exercise, education, exercise and education combined and furniture, which resulted in significant positive effects on different aspects of spinal health i.e. exercise only was most effective to address low back pain; education only was most effective to address spinal pain; exercise and education combined influenced neck and lower back pain the most and furniture adjustments impacted mostly neck and spinal pain. However, the grey literature lacked the scientific evidence base of support and the content of only two documents containing education on schoolbag weight and carriage could be incorporated in the schematic presentation of the evidence-based framework.

CONCLUSION: There was a trend that certain school-based interventions might be more beneficial to address certain aspects of spinal health in children and adolescents, despite conflicting results in the literature. The findings from the review can be used towards formulating recommendations for guidelines to be implemented in schools in future.

OPSOMMING

INLEIDING: Die prevalensie van spinaalpyn in kinders and adolosente is hoog en vermeerder met ouderdom. Kinders wat pyn ervaar tydens ‘n vroeë ouderdom, is geneig om pyn tydens adolosensie en selfs volwassenheid te ervaar. Risikofaktore wat moontlik kan bydra tot die ontwikkeling van spinalepyn sluit in die gebruik van skoolsakke, postuur, psigososiale faktore, ouderdom, geslag en skool meubels.

DOELWIT: 1) Om die effektiwiteit van skool-gebasseerde intervensies op spinale gesondheid in kinders en adolosente te bepaal, 2) om die effektiewe intervensies voor te lê in die vorm van ‘n skets as deel van die ontwikkeling van ‘n bewysgesteunde raamwerk.

METODE: Die studie bestaan uit twee fases: 1) ‘n sistematiese oorsig is uitgevoer om die effektiwiteit van die skool-gebasseerde intervensies op spinale gesondheid in kinders en adolosente te bepaal; 2) om ‘n skematiese voorlegging van die mees effektiewe intervensies te ontwikkel. Twee deeglike soektogte vir primêre navorsing (strategie A) en grys literatuur (strategie B), respektiewelik was uitgevoer vanaf die ontstaan van die databases tot en met Julie 2017. Slegs studies wat fokus op skool-gebasseerde intervensies wat beoog om spinale pyn in kinders en adolesente te voorkom, was in ag geneem. Die uitkomste in terme van spinale gesondheid, waarop gefokus is, sluit in vlakke van pyn of ongemak in die spinale area en enige meetbare komponente wat direk verwant is aan die spinale pyn of ongemak wat die individu se algehele welstand affekteer.

RESULTATE: Vier en twintig artikels is geidentifiseer in soektog A en ses grys literatuur dokumente is gevind met soektog B. Vier hoof intervensie temas is geidentifiseer naamlik: oefening, opvoeding alleen, oefening en opvoeding gekombineerd en vernaderinge aan skoolmeubels. Hierdie intervensies het almal

beduidende veranderinge veroorsaak op verskeie aspekte van spinaal gesondheid soos volg: oefening het ‘n beduidende positiewe effek op laerugpyn gehad; opvoeding het spinalepyn beduidend verminder; oefening en opvoeding gekombineerd het nekpyn en laerugpyn die meeste geaffekteer en die veranderinge in skoolmeubels het nekpyn en spinalepyn die meeste geaffekteer. Die grys literatuur het geen bewysgesteunde ondersteuning gehad nie en die inhoud van slegs twee van die dokumente, wat betrekking het tot opvoeding in terme van korrekte gebruik van skoolsakke kon by die skematiese voorlegging ingesluit word.

GEVOLGTREKKING: Daar is ‘n tendens van skool-gebasseerde intervensies wat ‘n positiewe impak op sekere aspekte van spinale gesondheid kan hê, selfs met die kontrasterende resultate in die literatuur. Die bevindinge van hierdie studie kan gebruik word om aanbevelings te maak vir riglyne wat by skole geimplementeer kan word om spinale gesondheid te bevorder.

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LIST OF ABBREVIATIONS

LBP:	Low back pain
NP:	Neck pain
NSP:	Neck-shoulder pain
UBP:	Upper back pain
IG:	Intervention group
CG:	Control Group
RULA:	Rapid Upper Limb Assessment
PEDro:	Physiotherapy Evidence Database
NHMRC:	National Health and Medical Research Council
NHI:	National Health Institute
UQMP:	Upper quadrant musculoskeletal pain
HRQOL:	Health related quality of life

Chapter 1

INTRODUCTION

1.1 Rationale and background

More than six million people across the world are affected by low back pain (LBP) and more than three million by neck pain (NP) [1]. The disabling effects of these conditions are reported in a press release in the Lancet which stated that musculoskeletal conditions, including back pain (BP), NP and osteoarthritis, are the second greatest cause of disability worldwide [1]. More concerning is the fact that of any health condition, LBP is the cause for the second most years lived with disability for adolescents between 15 and 19 years old with NP ranking at number eight according to the World Health Organisation (WHO) global burden of disease study [2]. It is therefore commended that research on spinal pain in children and adolescents has been receiving more attention recently [3-5], even though conventionally the focus has been on adults [3,4,6]. The health effects of spinal pain place a heavy financial burden on the economy [7-9]. Green [10] reported that the cost of neck and upper limb symptoms in terms of sick leave, decreased productivity and health care costs exceeded two billion Euros in the Netherlands. In 2002, healthcare costs related to treatment of back pain in children and adolescents in Germany alone, amounted to 100s of millions of Euros [11].

The alarmingly high prevalence of spinal pain in children and adolescents has been demonstrated in various studies [6-8,10]. A review by Louw et al. [9] reported a point, one-year and lifetime prevalence of LBP in African adolescents of 10-14%; 14-51% and 28-52% respectively. Chiwaridzo and Naidoo [5] reported on a lifetime prevalence in Zimbabwean adolescents between the age of 13 and 19 years old, of 42.9%. An epidemiological cross-sectional study done in Brazil, reported on a three-month BP prevalence of 55.7% in children between 11 and 16 years old [12]. LBP prevalence was reported at 37.8% in a group of primary school children in Uganda [13]. Neck pain prevalence estimates are high in adolescents ranging from 21% - 42% [14]. A cross-sectional study done by [15] demonstrated the increase in various areas of BP (i.e. LBP alone, NP alone and concomitant LBP and NP) and found a steady increase in the prevalence of concomitant LBP and NP from 1991 – 2011 amongst Finnish adolescents. This study showed that the prevalence increased at a higher rate for females than it did for males [15]

Studies show that back pain starts early in life [16] and increases with age [5-7,17-19] with spinal pain prevalence in adolescence at 18 years approaching that of adults [17]. Thus, spinal pain in children and adolescents is likely to cause spinal pain in adulthood [5,15-19] and recurrent episodes during adolescence are associated with chronic pain in adulthood [3,6,17]. It is safe to say that an approach to prevent disease is better than to treat or cure disease. Thus, it would be valuable to identify and understand the various risk factors associated with the development of spinal pain in children and adolescents. The following risk factors are commonly identified in the literature: age, gender, psychosocial factors and mental health, schoolbags, posture, furniture and anthropometrics, screen-based activities, nutrition, weight and physical activity. [20,24,25].

The next section aims to provide more insight on the risk factors that are associated with spinal pain in adolescents and children. By identifying the risk factors and understanding the challenges that adolescents and children face in terms of spinal health, will assist with understanding the current treatment practices and/or the lack of certain aspects when addressing spinal pain in children and adolescents.

1.2 Risk factors associated with spinal pain in children and adolescents

Age and gender

The evidence for age and gender as potential risk factors for the development of spinal pain is inconsistent. A systematic review by Trevelyan and Legg [25] reported that age and gender are associated with spinal pain in children and adolescents between the ages of eleven and fourteen years. The authors found that the prevalence of spinal pain increases with age, particularly after twelve years of age, and that the prevalence in females is often higher than in males [25]. Kjaer et al. [16] reported an increase in spinal pain prevalence from 33% in nine-year-old children to 48% in fifteen-year-old children. On the contrary Noll et al. [12] concluded that there was no correlation between increased age and a higher prevalence of spinal pain. Girls between the age of eleven and sixteen years had a higher spinal pain prevalence compared to boys ranging from 55% to 75% in girls and 45% to 55% in boys [12]. Rees et al. [26] found that Australian adolescent girls had a higher NP prevalence (17.3%) and co-morbid neck and back pain prevalence (17.6%) compared to prevalence rates in boys of 13.8% and 9.1% respectively. Chiwaridzo and Naidoo [3] on the other hand, found that spinal pain prevalence increases with age, but that both genders were affected equally in Zimbabwean adolescents. In the review by Calvo-Munoz et al. [4], the authors found no significant difference between gender and LBP lifetime prevalence and could not conclude that females had a higher prevalence than males. Despite the conflicting findings in the literature regarding the role of age and gender on the presence of spinal pain, Wang et al. [27] and Lardon et al. [28] reported that the gender difference could be attributed to puberty (when age and gender were controlled for), hormonal changes and psychological factors such as depression and social problems [24].

Psychosocial factors and mental health

Psychosocial and mental health problems are related to back and neck pain in the younger population [24,26]. Myrtveit et al. [14] found that depression was associated with neck and shoulder pain in adolescents. Similar findings were reported in a systematic review by Prins et al. [29] i.e. psychosocial factors such as depression, mental distress and psychosomatic complaints contributed to upper quadrant musculoskeletal pain (UQMP) in children and adolescents. Emotional problems, negative psychosocial experiences and behavioural problems have also been associated with LBP in children [30].

Schoolbags

A lot of emphasis has been placed on the effect of schoolbags on spinal health in children and adolescents. According to Moore et al. [31], the ideal schoolbag weight should not exceed 10% of the child or adolescent's body weight to prevent spinal pain because spinal pain, due to schoolbag weight, is associated with increased healthcare seeking behaviour and absenteeism from school and sport activities in children and adolescents aged eight to eighteen years. An increase in schoolbag weight could cause changes in the lumbar disc height and curvature and contribute to a significant amount of spinal pain experienced by children [32]. In another study, the authors found that carrying a schoolbag increased forward head posture which lead to pain in the cervical and thoracic spinal regions [33]. However, Dockrell et al. [34] reported that psychosocial factors, gender and a history of spinal discomfort were more associated with schoolbag-related back or shoulder discomfort than the physical factors such as schoolbag weight and the duration of carriage. Similar results were reported by van Gent et al. [35] where the authors established that psychosomatic factors had a stronger relationship with the incidence of neck and/or shoulder and low back complaints than the physical factors of carrying the schoolbag.

Posture

Lazary et al. [8] described posture as *"the most conspicuous sign of spinal health"* and the review reports on the evidence for and against the correlation between posture and spinal pain. The review suggests investigation into exercise-based primary prevention interventions focussing on posture correction to prevent LBP as the authors argued that poor posture is associated with muscle imbalance and altered muscle function and therefore posture correction could decrease LBP [8]. Kelly et al. [36] reported on school children's posture when using computers at school and found that none of the students' posture were in an acceptable range according to the Rapid Upper Limb Assessment (RULA) tool and that students reported discomfort from the beginning to the end of the computer class, irrespective of the duration of the class (i.e. 40 minutes vs. 80 minutes). Children were more at risk of experiencing LBP if they sat with a forward flexed spine against or away from the chair or with an extended spine away from the chair at home and at school [37]. Minghelli et al., [37] also reported an increased risk of LBP if these children stood incorrectly with an increased thoracic kyphosis or hyperextension of the lumbar area. Brink and Louw [38] investigated the relationship between sitting and UQMP in children and adolescents and described various postural angles during sitting that were associated with UQMP such as: extreme cervical and thoracic flexion or extension angles, increased trunk flexion and increased lumbar extension and anterior pelvic tilt angles. The review also found that activities such as computer use, writing, watching television and prolonged static sitting for more than four hours resulted in mild to severe NP [38]. Sitting posture and its relationship to neck, upper back and LBP in children were also investigated in a study by Murphy et al. [39] that found trunk flexion angles of greater than twenty degrees to be associated with an increased likelihood of LBP reports and that static sitting posture increased the levels of neck and upper back pain. The results of the study were in accord with those of Brink and Louw [34] and Prins et al. [29] confirming that the duration of sitting in the classrooms were too long and had a significant association with LBP.

Furniture and anthropometrics

School furniture and anthropometrics also play a role in spinal pain in children and adolescents. Studies have reported a mismatch in classroom furniture and anthropometrics in children which could lead to a less favourable learning environment affecting learners negatively, causing fatigue, spinal discomfort and poor posture [40 - 42]. Children sat on chairs with seats that were either too high or too deep or in front of desks that were too high [40, 41]. Van Niekerk et al. [43] investigated school furniture dimensions in computer laboratories and the anthropometrics of high school students in the Western Cape metropole of South Africa and found a significant mismatch between the two: most students did not match their seat in terms of the chair depth. This shows that the mismatch of school furniture and anthropometrics of school children have been problematic for almost two decades.

Screen-based activities

Screen-based activities such as spending time watching television, playing games on the computer or working on a computer are associated with neck and shoulder pain in adolescents [14,44]. Girls who watched television for more than two hours a day reported severe NP [38]. In a group of 156 sixth graders, more than half of the children reported some form of musculoskeletal discomfort which were made worse by computer use [45]. Silva et al. [46] also found that computer use was associated with the increased likelihood of reporting LBP amongst adolescents in Portugal. Straker et al. [47] reviewed the physical aspects of computer use by children and found that children are often absorbed in their task and may ignore and/or fail to respond to symptoms of discomfort.

Nutrition, weight and physical activity

Perry et al. [48] found that the consumption of certain food groups or nutrients such as Vitamin B12, egg, cereal and meat may be associated with spinal pain in adolescents. Females with a low intake of Vitamin B12 were at greater risk of developing NP, whereas males had a higher risk of developing NP with high or low consumption of cereals [48]. The review by Cardon and Balague [21] found no evidence of an association between increased BMI and LBP however, Calvo-Muñoz et al. [49] found that a higher BMI was associated with a higher LBP prevalence in children and adolescents. Silva et al. [46] reported that LBP was associated with increased time spent on moderate physical activity per week and that mid back pain was significantly associated with vigorous physical activity. Limon et al. [20] reported that increasing physical activity to prevent LBP is questionable, but the authors suggested that non-strenuous physical activity should be performed regularly to maintain and improve trunk muscle strength and endurance to prevent LBP. Skoffer et al. [50] conducted a cross-sectional retrospective study and established that more sports activity did not necessarily lead to the less LBP, but that there is an association between inactivity (such as being transported to school instead of walking and increased time spent watching television) and LBP.

1.3 Interventions addressing spinal pain in children and adolescents

When risk factors have been identified, it can assist in formulating preventative strategies and/or treatment modalities. With increased prevalence of spinal pain from a young age potentially leading to spinal pain in adulthood, it is imperative to address the risk factors as early as possible. Previous systematic reviews investigated the effectiveness of curative or preventative interventions on spinal pain in children and adolescents of which three reported on school-based interventions [21,22,51] and two on a combination of school-based and non-school-based interventions [19,45]. The school-based interventions included components such as 1) education on the anatomy and physiology of the spine, 2) back care principles, 3) exercise, 4) posture correction, 5) postural hygiene and 6) education on carrying of schoolbags [21,22,51] whereas the non-school-based interventions included physical conditioning, manual therapy, individualised therapy and self-training [19,52]. The studies included in the reviews measured outcomes such as knowledge about the spine and/or spinal care; spinal behaviour, pain prevalence [4,21,22,51]; pain intensity, disability, participation in daily activities, well-being and adverse effects [52]. According to Calvo Munoz et al. [19], physical conditioning and manual therapy (outside of school) were most effective in treating LBP in children. On the other hand, school-based interventions, which included back-education programs, significantly increased the students' learned spinal behaviour and knowledge but were ineffective in reducing the prevalence of LBP in children and adolescents [51] whereas school-based exercise interventions effectively reduced LBP prevalence [25,22]. However, the authors concluded the evidence to be questionable due to the poor methodological quality of the reviewed studies [19,51] and that the limited number of studies affects the generalisability of the results [22] and the formulation of evidence-based guidelines [25].

It is clear from the literature that a lot of the focus of spinal health in children and adolescents has been on identifying the problem and recording the magnitude of the issue around spinal pain in children and adolescents. Although attempts have been made to address the problem as is demonstrated in the various reviews mentioned above, there is still no conclusive evidence about the most appropriate or correct way to manage (prevent and treat) spinal pain in the younger population. In Europe, the COST Action B13 program was established with the aim of developing guidelines to prevent LBP in Europe amongst three populations: the general population, children and the workforce [25]. Unfortunately, the working group of the COST B13 action could not gather sufficient evidence for specific prevention strategies for LBP in children and no recommendations for LBP prevention could be made.

The high prevalence of spinal pain and the unavoidable potential risk factors of spinal pain warrant the development and implementation of guidelines to promote spinal health in children and adolescents. According to Woolf et al. [53], clinical guidelines have the potential to minimise morbidity and mortality and as such improve health outcomes and quality of life. As children and adolescents spend most of their day and most of their childhood and adolescent years at school, it seems an appropriate environment to pursue the implementation of spinal health promotion strategies [7,54,55]. A guideline which could be implemented at school (and at home) will assist children and adolescents, their parents, teachers and various other stakeholders to decrease the high prevalence of spinal pain in children and adolescents and as such decrease the economic burden associated with spinal pain. This is expected to have a positive impact on the prevalence of spinal pain in adults and may contribute to better quality of life amongst these populations.

To our knowledge there are no evidence-based guidelines to promote spinal health in children and adolescents. Thus, the aim of the study is to conduct a systematic review on the effectiveness of school-based interventions on spinal health in children and adolescents. This systematic review forms part of a bigger project and will be the first step in the development and design of a guideline document which could be implemented in South African schools as part of spinal health promotion amongst children and adolescents. The first step of the guideline development is to collect and synthesise the data to be presented for further scrutiny by experts and will be incorporated into the bigger project of which various other aspects will be included.

Chapter 2

ARTICLE

The Effectiveness of School-Based Interventions on Spinal Health in Children and Adolescents: A Systematic Review

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ABSTRACT

BACKGROUND: Spinal pain prevalence in children and adolescents is high, increases with age and may lead to spinal pain in adulthood. Potential predisposing factors for spinal pain in children and adolescents are the usage of schoolbags; posture; sitting duration; psychosocial factors; age; gender and school furniture.

PURPOSE: 1) To determine the effectiveness of school-based interventions in promoting spinal health in children and adolescents; 2) to present a schematic presentation of the effective interventions as part of development of an evidence-based framework.

METHODS: This study had two phases: 1) conducting a systematic review on the effectiveness of school-based interventions to promote spinal health in children and adolescents, 2) developing a schematic presentation of the evidence-based framework depicting the effective school-based interventions. Two comprehensive search strategies for primary research (strategy A) and grey literature (strategy B) respectively, were performed. School-based interventions which aims were to prevent poor spinal health and/or improve spinal health in school children and adolescents were considered. Spinal health outcomes included levels of pain or discomfort limited to the spinal area and other measurable components which is a direct result of the spinal pain/discomfort and which affects the individual's optimal experience of a sense of well-being.

RESULTS: Search strategy A yielded 24 eligible articles and search strategy B, six documents of grey literature. Four main themes of intervention were identified i.e. exercise, education, exercise and education combined and furniture, which resulted in significant positive effects on different aspects of spinal health i.e. exercise only was most effective to address LBP; education only was most effective to address spinal pain; exercise and education combined influenced neck and lower back pain the most and furniture adjustments impacted mostly neck and spinal pain. However, the grey literature lacked the scientific evidence base of support and the content of only two documents containing education on schoolbag weight and carriage could be incorporated in the schematic presentation of the evidence-based framework.

CONCLUSION: There was a trend that certain school-based interventions might be more beneficial to address certain aspects of spinal health in children and adolescents, despite conflicting results in the literature. The findings from the review can be used towards formulating recommendations for guidelines to be implemented in schools in future.

Keywords: spinal health, back pain, neck pain, spinal pain, school children, adolescents, well-being, school-based interventions

INTRODUCTION

Spinal pain in children and adolescents is reported on extensively in the literature [15,17,21,51,52,56]. The prevalence of spinal pain in children and adolescents is high, ranging from 33% to 48% [4-6,7,12,18] and increases with age [6,16,17]. Children who experience spinal pain early in life are likely to experience pain during adolescence and even into adulthood [5-7,16].

Child and adolescent spinal health is a great public health concern as is evident from the widely described impact of spinal pain on school children's well-being. In the study by O'Sullivan et al. [9] LBP in adolescents at the age of seventeen years was correlated with healthcare-seeking behaviour, use of medication, school absenteeism as well as poor physical and mental health related quality of life (HRQOL) [9]. Adolescents with neck and shoulder pain (NSP) made use of healthcare services (general medical practitioner and school health services) considerably more than those who did not have NSP [14]. In a cohort study of Danish children, Kjaer et al. [16] found that reports of spinal pain increased rapidly after the age of thirteen years, as well as healthcare seeking behaviour.

The aetiology of spinal pain in children and adolescents is multifactorial and potential predisposing factors are the usage of schoolbags; posture; sitting duration; psychosocial factors; age; gender and school furniture [8,14,20,24]. The effect of schoolbag weight, use of schoolbags and duration of schoolbag use have been researched extensively with conflicting findings [34,57-61]. The appropriate schoolbag weight to minimise spinal pain and the association between schoolbags use and spinal pain, are still undetermined [58]. Other factors that may contribute to or influence spinal pain in children and adolescents include psychosocial factors such as depression; behavioural problems [24]; exercise (the lack of/too much thereof) [22,25]; furniture [22,25,62] the lack of knowledge and information amongst school children and parents [4] and postural behaviour [12,63]. Murphy et al. [63] investigated postural behaviour and found an association between trunk flexion more than twenty degrees and LBP as well as an association between static postures and neck and upper back pain. An epidemiological population study illustrated a positive association between various postures such as sitting for long periods of time with forward trunk flexion; lack of lumbar support and arm support; inadequate sitting when using a computer or whilst writing; and non-neutral lying posture and back pain in children and adolescents [12].

Literature has shown that spinal pain during childhood is a strong predictor for back pain experienced in adulthood [5,7] and with its impact on morbidity and disability, spinal pain places a high demand on society and the economy [9,64]. It is therefore imperative that the promotion of spinal health is embarked on as early as possible. Three systematic reviews investigated the effectiveness of school-based interventions on treating or preventing spinal pain in children and adolescents [21,22,51]. These interventions included components such as 1) education on the anatomy and physiology of the spine, 2) back care principles, 3) exercise, 4) posture correction, 5) postural hygiene and 6) education on carrying of schoolbags [21,22, 51]. Back-education programs significantly increased the students' learned spinal behaviour and knowledge but were ineffective in reducing the prevalence of LBP in children and adolescents [51] whereas exercise interventions effectively reduced LBP prevalence [21,22]. However, the reviews concluded that too few studies have been performed and that the methodological quality of the reviewed studies was poor thus affecting the generalizability of the findings and impeding the development of evidence-based guidelines [21,22,51].

Various studies have reported on the lack of homogeneity in defining spinal pain or the impact thereof amongst children and adolescents [17,6]. Furthermore, an epidemiological study by Jeffries et al. [8] found that spinal pain is often grouped in various combinations of anatomical areas (neck, upper back, mid back, lower back, shoulders). The National Institutes of Health (NIH) defines spinal (back) pain as a symptom of a medical condition, and not a diagnosis itself [65]. The World Health Organisation (WHO) defines health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" [66] whereas well-being pertains to quality of life and encompasses a state of fulfilment when people can fulfil their personal and social goals [64]. Well-being is multi-dimensional and in children it relates to happiness, sense of security, good self-image and having a good physical environment amongst other things [67]. Therefore, the aim of this review was to determine the effectiveness of school-based interventions in promoting spinal health in children and adolescents where spinal health is defined as an individual's sense of well-being due to the absence or lack of spinal pain or discomfort.

The objectives of the systematic review were:

1) To describe the school-based interventions implemented to promote spinal health in children and adolescents
2) To describe the outcome measures used to measure spinal pain in children and adolescents

3) To synthesize the evidence and determine the effectiveness of school-based interventions to promote spinal health in children and adolescents
4) To develop a schematic presentation (framework) of the evidence of school-based interventions for promoting spinal health in children and adolescents based on the evidence synthesis

METHODOLOGY

This study consisted of two phases of which the first was to conduct a systematic review on the effectiveness of school-based interventions to promote spinal health in children and adolescents. The second phase entailed the development of a schematic presentation of the evidence-based framework depicting the effective school-based interventions.

Phase one: Systematic review

The PRISMA checklist [68] was used for the reporting of this review. The search method included a search on primary and secondary research as well as grey literature since *“public health literature is widely dispersed”* and all available and eligible literature needed to be sourced [69]. Therefore, this review has two search strategies; A (primary and secondary research) and B (grey literature).

Search strategy A

A comprehensive search was performed from inception of databases to July 2017 using electronic databases such as Biomed Central, CINAHL, Cochrane Library, Google Scholar, PEDro, ProQuest, PUBMED and Science Direct accessed through Stellenbosch University’s library. The following search terms were used in various combinations: back pain, neck pain, physiotherapy, physical therapy, children, adolescent, exercise, school, ergonomics, posture, education, back packs or schoolbags, furniture and intervention. Medical subject headings (MeSH) terms were used in PUBMED. Secondary searching (Pearling) was performed when the reference lists of the retrieved articles were screened. The titles, abstracts and full text versions of potentially eligible articles were screened by one reviewer (RM). An example of a search strategy, as performed in the PUBMED database is illustrated in Table 1. The complete search strategies for all the databases can be found in Appendix A.

Table 1: PUBMED search strategy

Database	Limits	No.	Search terms	Hits
PUBMED	Full text, Humans, English, Adolescent: 13-18 years, Child: 6-12 years; MeSH terms: "neck pain", "back pain"; Date: inception to 01/07/2017	1	neck pain and back pain	49
		2	neck pain OR back pain AND guidelines	99
		3	neck pain OR back pain AND (school children)	263
		4	#3 AND adolescent	195
		5	#4 AND posture	31
		6	#4 AND exercise	24
		7	#4 AND physiotherapy	23
		8	#4 AND education	46
		9	#4 AND (back pack) OR schoolbag	31
		10	#4 AND ergonomics	11
		11	#3 AND ergonomics	20
		12	#3 AND intervention	156

Inclusion and exclusion criteria for search strategy A

Studies that included male and female children and adolescents between the ages of six and eighteen years were eligible for this review. The following types of studies were included: Randomised Control Trials (RCT's), quasi-experimental studies, pre-and post-test studies, case-control studies and case studies. Only full text articles published in English were selected. The following school-based interventions which aims, or objectives were to prevent poor spinal health and/or improve spinal health in school children and adolescents were considered for inclusion such as but were not limited to: educational programmes; modifications to classrooms, workstations, or furniture; and flexibility and/or strengthening exercises. Spinal health could be the primary or secondary outcome of the study. Spinal health outcomes of interest were levels of pain or discomfort limited to the spinal area (including lower back, upper back, neck and neck-shoulder pain) and other measurable components which is a direct result of the spinal pain/discomfort and which affects the individual's optimal experience of a sense of well-being and could include components such as but were not limited to: absenteeism from school and seeking medical treatment due to spinal pain. If the study included subjects who complained of spinal pain related to serious injury, pathology or neurological fall outs, the study was excluded. Studies that did not include spinal health outcomes as described previously, were excluded from this review.

Search strategy B

A search was performed from inception up to July 2017 using various Guideline Clearinghouses as well as databases accessed via the Stellenbosch University's library. These Guideline Clearinghouses and databases included: Google, New Zealand Guidelines Group; University of Ottawa Rehabilitation Guidelines; Physiotherapy Evidence Database (PEDro); Physical therapy grey literature; Grey literature physical therapy guide; National Institute for Health and Clinical Excellence; National Health Services (NHS) Evidence; The Murdoch Children's Research

Institute Centres of Research Excellence; The GREAT Network; The EQUATOR Network; National Health and Medical Research Council (NHMRC); The Cochrane Collaboration and Australasian Cochrane Centre. Different combinations of the following search terms were used: back pain, neck pain, physiotherapy, therapy, physical therapy, children, adolescent, ergonomics, posture, education, back packs and schoolbags. All the titles, abstracts, policy or guideline documents and full text articles were screened by one reviewer (RM) for eligibility for this review.

Inclusion and exclusion criteria for search strategy B

Evidence based guideline documents, policy documents or educational pamphlets that provide information on school-based interventions or treatment modalities, which aimed at promoting spinal health in school children and adolescents, were eligible for inclusion in this review. Policy documents, pamphlets or guideline documents that focus on spinal health in adults or other populations such as treating spinal pain in children due to injury or pathology (eg. cancer, TB), spinal cord compression, fractures, trauma or any neurological deficits were excluded from this study.

Hierarchy of evidence

The National Health and Medical Research Council (NHMRC) hierarchy of evidence was used to assess the level of evidence of the included articles from search strategy A [70]. Table 2 describes the different levels of evidence.

Table 2: NHMRC hierarchy of evidence for effectiveness

Level	Description of studies
I	A systematic review of level II studies
II	A randomised controlled trial
III-1	A pseudo-randomised controlled trial (i.e. alternate allocation or some other method)
III-2	A comparative study with concurrent controls: • Non-randomised, experimental trial • Cohort study • Case-control study Interrupted time series with a control group
III-3	A comparative study without concurrent controls: • Historical control study • Two or more single arm studies Interrupted time series without a parallel control group
IV	Case series with either post-test or pre-test/post-test outcomes

Methodological appraisal

Due to the different article types that have been included for review under search strategy A, eligible articles were grouped according to the study design, i.e RCTs and quasi-experimental studies (non-RCTs). Appropriate appraisal tools were used for the different types of studies. The PEDro scale (Appendix B) was used to appraise the methodological quality of the RCTs. This scale is based on a Delphi list and is one of the most frequently used scales to assess RCTs in physical therapy trials [71]. The PEDro scale consists of 11 questions which are scored with either yes/no answers and although there are eleven questions, the score is only calculated out of ten. The first criterion on the scale does not form part of the total score and was only included to ensure that all the Delphi list items are present on the scale [72].

The Johanna Briggs Institute (JBI) checklist for quasi-experimental studies (Appendix C) was used to appraise quasi-experimental studies. The checklist for quasi-experimental studies consists of nine questions. These checklists were designed to assist researchers to determine the probability of bias of the respective studies and as such assist with synthesis and analysis of the study results. Questions could be answered with “yes, no, unclear or not applicable”. The appraisals were done by one reviewer (RM) and where there was any uncertainty, the findings were discussed with the second reviewer (YB).

Data extraction

Data was extracted, using a Microsoft (MS) Excel spreadsheet with the following headings for search strategy A: title, author(s), publication year, country, study design, sample size, sample composition (gender), description of intervention and comparison, description of the development of the intervention (who developed the intervention and whether stakeholders were involved in the development of the intervention), duration and frequency of intervention, outcome measures, outcome measurement tool(s), follow-up period and results. The headings for search strategy B were as follows: title, author(s), year published, country, study design/type of document, type of intervention, content of the document, implementation of content, development of policy document/guidelines (who developed the intervention and whether stakeholders were involved in the development of the intervention) and supporting scientific sources.

Data analysis and synthesis

The types of interventions and its implemented time frame, outcome measures and outcome measurement tools varied between the studies obtained from search strategy A, thus a meta-analysis could not be performed, and the data was analysed descriptively using tables. The extracted data were grouped according to the main themes of intervention. The analysed data was further synthesized by scrutinising the amount of studies per intervention theme, the study sample size and the effectiveness of the intervention. The effectiveness of an intervention was based on inferences of statistical significance of the study results (p-values; confidence intervals, odd ratios or effect size). The statistical significance and within- or between-group differences were considered. Table 3 shows how the effectiveness of the interventions on the various outcomes was presented.

Table 3: Indicators for the effectiveness of interventions

Sign	Description in terms of effectiveness
++	A positive statistically significant difference between intervention and control groups or a positive significant difference within the intervention group when the study design allowed for only one group (no control group)
+	A positive significant difference within the intervention group (both intervention and control groups are described)
°	The intervention group remained unchanged
-	The intervention group worsened, but not statistically significant
- -	A statistically significant negative effect on the intervention group

The effectiveness of the interventions was tabulated according to short- or long-term effects, where short term effect was considered up until three months and long term as longer than three months. Figure 1 describes the process followed for the data analysis and synthesis of the results.

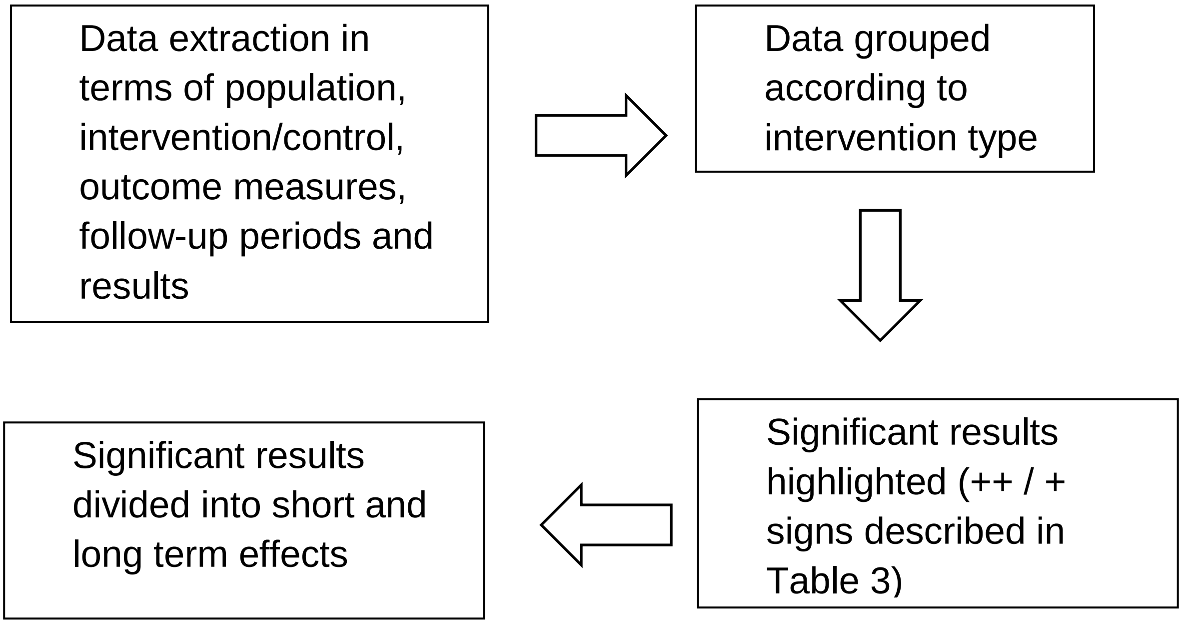

Figure 1: Steps followed for data analysis and synthesis

During the data synthesis process, none of the information obtained from search strategy B (grey literature) could be incorporated with the evidence obtained from search strategy A due to the variability of the format in which the eligible documents were presented. However, the data was considered during the second phase of the study where the schematic presentation of the evidence was developed. Only grey literature content, supported by a scientific evidence base were considered appropriate for inclusion in the schematic presentation (framework).

Phase two: Development of a schematic presentation (framework) of the evidence

This section reports on the steps followed to create a visual representation (framework) of the current best evidence of school-based interventions for promoting spinal health in children and adolescents. In line with the theme of school-based interventions, a picture of a school building was used to depict the findings, which resulted from the systematic review to formulate the current best evidence of effectiveness. These findings will be used towards formulating guidelines as part of the bigger project of which this review is the first step. The interventions linked to the best evidence of effectiveness (those results emanating from studies receiving ++ or + as depicted in Table 3) were displayed according to the spinal health outcomes related to the area of the spine i.e. back pain, neck pain and spinal pain. The roof of the school building indicates whether the results were related to short or long-term effectiveness, the windows display the most effective interventions linked to the respective spinal health outcomes and the steps represent the information obtained from the grey literature. Two school buildings were used to illustrate the short- and long-term effectiveness of the interventions separately.

RESULTS

Phase one – Systematic Review: Search strategy A

A comprehensive search across eight databases was conducted by one reviewer. A total number of 6817 hits were produced of which 6682 were excluded based on the title of the article. One hundred and thirty-five potential articles were screened for eligibility of which 73 were duplicates. Of the remaining 62 articles, 41 articles were excluded based on the information in the abstract and/or because the study design, aim, outcome measures or setting were inappropriate. One article was excluded [73] as a duplicate because the intervention, sample, setting and primary outcomes and results for the primary outcomes were identical to Jones at el. [74]. The only difference was the secondary outcomes that were reported on: Jones et al. [74] reported on "daily inactivity" which was more appropriate to this review than the "biological risk indicators" that were reported on in Jones et al. [73]. The database search yielded 22 eligible articles [75-93,96,97]. An additional two articles were retrieved by means of

PEARLING [91,92]. A total of 24 primary research articles were included in this review.

No systematic reviews were included in the review.

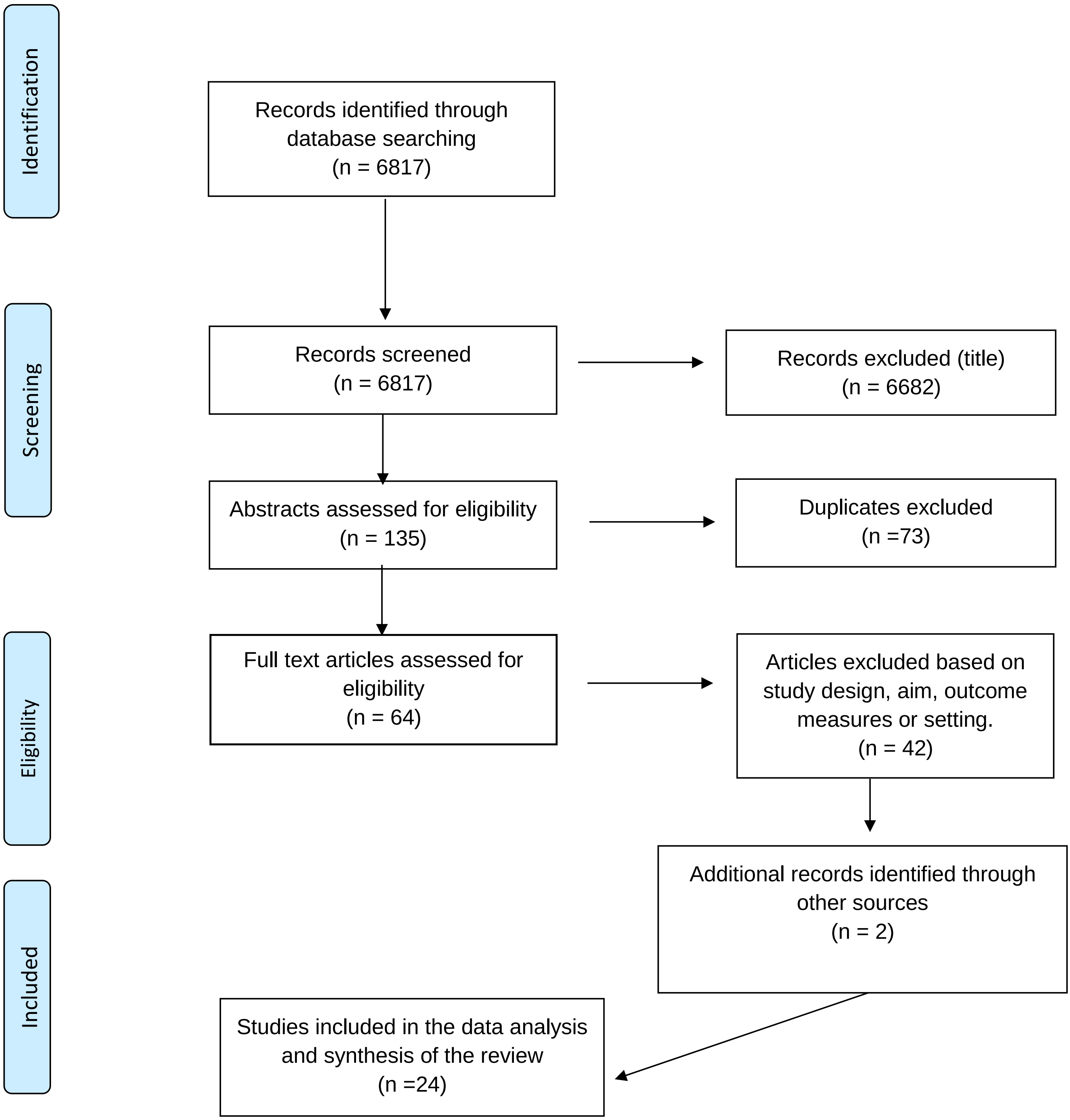

Figure 2: Prisma flow diagram illustrating the search results (Search strategy A)

Description of the studies

A description of the study characteristics in terms of title, author, country, study design, sample size and study aim, is presented in Table 4. Most of the studies (n=16) were conducted in Europe [74,75,77,80,81,83-89,92-95]. Seven of the European studies were conducted in Belgium and/or Denmark [80,84-87,88,89,92] and had a similar sample population, setting, interventions and outcomes. Only one study was conducted in South Africa [78]. The other studies were conducted in New Zealand [76], India [96] Egypt [97]; Malaysia [79] and the USA [82,90,91]. Five of the studies [74-78] were RCT's and the remaining 19 studies were quasi-experimental studies. Five studies used only one group [81,82, 90, 91,96] whereas two studies incorporated three groups [84,93] and the other 17 studies included two groups (intervention and control groups). The sample size varied from 20 participants to 708 participants and both male and female participants were included in all the studies.

Table 4: Study characteristics

Study ID	Title	Authors	Country	Study design	Sample size	Age	Aim of the study
1	Effects of a Resistance and Stretching Training Program on Forward Head and Protracted Shoulder Posture in Adolescents	Ruivo et al., 2017	Portugal	RCT	115 (76 IG + 39 CG)	15 – 17 years	To evaluate the effects of a 16-week resistance and stretching training program on FHP and PSs and neck and shoulder pain in Portuguese adolescents aged 15-17 years.
2	Daily Exercises and Education for Preventing Low Back Pain in Children: Cluster Randomized Controlled Trial	Hill and Keating; 2015	New Zealand	RCT	708 (469 IG + 239 CG)	8 – 11 years	To determine the effect of education and daily exercise compared with education alone on LBP episodes in children
3	Effect of a high-density foam seating wedge on back pain intensity when used by 14 to 16-year-old school students: a randomised controlled trial	Candy et al., 2012	England	RCT	185 (93 IG + 92 CG)	14 – 16 years	To test the effect of the use of a high-density foam wedge on the intensity of BP compared to traditional seating in 14- to 16-year-old school students
4	Exercise reduces the intensity and prevalence of low back pain in 12–13-year-old children: a randomised trial	Fanucchi et al., 2009	South Africa	RCT	72 (39 IG + 33 CG)	12 – 13 years	To determine the effectiveness of an eight-week exercise program on intensity and prevalence of LBP, childhood physical risk factors for LBP and sense of well-being in 12–13-year-old children
5	Recurrent non-specific low-back pain in adolescents: the role of exercise	Jones et al., 2007a	UK	RCT	54 (27 IG + 27 CG)	13 – 15 years	To evaluate the efficacy of an exercise programme for recurrent NLSBP in adolescents
6	Effects of sitting posture modification and exercises in school going children with neck pain in rural area in Tamil Nadu	Rupesh et al., 2016	India	Quasi-experimental	25	10 – 14 years	To determine the effectiveness of sitting posture modification and exercises on NP in school children
7	Impact of School Bag Use Instructional Guidelines on Primary School Children's Awareness and pain experience	Ebtesam ME Ebied, 2015	Egypt	Quasi-experimental	100 (50 IG + 50 CG)	8 – 12 years	To assess the effectiveness of schoolbag, use instructional guidelines on awareness and pain experience in primary school children
8	Poor sitting posture and a heavy schoolbag as contributors to musculoskeletal pain in children: an ergonomic school education intervention program	Syazwan et al., 2011	Malaysia	Quasi-experimental	153 (78 IG and 75 CG)	8 years and 11 years	To evaluate the effectiveness of a basic educational training program emphasizing exercise for reducing ergonomic risk factors contributing to musculoskeletal pain in children aged 8 and 11 years
9	Long-term effectiveness of a back-education programme in elementary schoolchildren: an 8-year follow-up study	Dolphens et al.; 2011	Belgium	Quasi-experimental	194 (96 IG + 98 CG)	9 – 11 years	To investigate the long-term effectiveness of a spinal care education programme in improving back care-related knowledge, spinal care behaviour, self-efficacy towards proper back care behaviour, spinal pain and fear-avoidance beliefs in 9 – 11-year-old schoolchildren
10	Computer-related posture and discomfort in primary school children: The effects of a school-based ergonomic intervention	Dockrell et al., 2010	Ireland	Quasi-experimental	23	9 – 10 years	To investigate the effectiveness of an ergonomic intervention on posture, discomfort and pain in school children
11	Backpack load limit recommendation for middle school students based on physiological and psychophysical measurements	Bauer and Freivalds, 2009	USA	Quasi-experimental	20	11 – 14 years	To determine the effects of different back pack weights during walking and standing on posture, heart rate, perceived exertion and pain perceptions to determine an acceptable backpack load limit for middle school students
12	Do ergonomically designed school workstations decrease musculoskeletal symptoms in children? A 26-month prospective follow-up study.	Saarni et al., 2009	Finland	Quasi-experimental	101 (IG and CG NR at baseline)	12 and 14 years (mean)	To investigate the effectiveness of ergonomically designed workstations compared to conventional workstations on musculoskeletal pain symptoms in schoolchildren
13	Back education in elementary schoolchildren: the effects of adding a physical activity promotion program to a back-care program	Cardon et al., 2007	Belgium	Quasi-experimental	555 (190 Ex and Ed + 193 Ed + 172 CG)	8.1 – 12 years	To evaluate the effects of combining a back-care program with a PA promotion program on back care knowledge, back care related behavior, fear-avoidance beliefs, BP and PA levels in elementary schoolchildren

IG: Intervention Group; CG: Control Group; LBP: Low Back Pain; FHP: Forward Head Posture; PSs: Protracted Shoulders; Ex: Exercise; Ed: Education; PA: Physical Activity; BP: Back Pain; NP: Neck Pain

Table 4: Study characteristics (continued)

Study ID	Title	Authors	Country	Study design	Sample size	Age	Aim of the study
14	**Back posture education in elementary schoolchildren: a 2-year follow-up study**	**Geldhof et al., 2007a**	**Belgium**	**Quasi – experimental**	**195 (94 IG + 101 CG)**	**13 – 14 years**	**To investigate the effects of a back-education program at 2-year follow-up on back posture knowledge, fear-avoidance beliefs and self-reported pain and to evaluate which aspects of postural behavior were integrated in the lifestyles of children aged 13–14 years**
15	Back posture education in elementary school children: stability of two-year intervention effects	Geldhof et al., 2007b	Belgium	Quasi-experimental	398 (121 IG + 124 CG)	8 – 11 years	To evaluate the stability of a multifactorial back education program's effectiveness on children's back posture knowledge, fear-avoidance beliefs, and BP reports following a 2-school year back education program
16	Sitting and standing postures are corrected by adjustable furniture with lowered muscle tension in high-school students	Koskelo et al., 2007	Finland	Quasi-experimental	30 (15 IG + 15 CG)	16 – 18 years	To determine the effectiveness of the use of adjustable school desks and chairs on sitting and standing postures, trunk muscle strength, muscle tension during classes, pain levels (neck-shoulder, LBP, headache) and learning, compared to traditional furniture, in 16–18-year-old high-school students
17	Effects of a Two-School-Year Multifactorial Back Education Program in Elementary Schoolchildren	Geldhof et al., 2006	Belgium	Quasi-experimental	365 (193 IG + 172 CG)	9 – 11 years	To investigate the effects of a 2-school-year multifactorial back education program on back posture knowledge, postural behaviour, BP or NP and fear-avoidance beliefs in elementary schoolchildren.
18	Sitting habits in elementary schoolchildren: a traditional versus a "Moving school"	Cardon et al., 2004	Belgium and Germany	Quasi-experimental	47 (22 IG + 25 CG)	?8 years	To evaluate the effectiveness of the "Moving School" - programme on self-reported back and NP compared to a traditional school in elementary school children
19	Does the introduction of a simple wedge to school seating reduce adolescent back pain?	Candy et al., 2004	England	Quasi-experimental	48 (22 IG + 26 CG)	16 – 18 years	To investigate the effect of the use of a high-density foam wedge on the intensity and frequency of BP compared to traditional seating in school children aged 16 – 18 years
20	Effectiveness of a school-based backpack health promotion program: *Backpack Intelligence*	Goodgold and Nielsen, 2003	USA	Quasi-experimental	252	6th and 7th grade (age unknown)	To determine the effectiveness of a school-based backpack health promotion program *(Backpack Intelligence)*, on prevalence and recurrence of BP, self-reported knowledge of backpack safety, behaviour changes, and belief that improper backpack use can cause injury in 6th and 7th grade students
21	Backpack intelligence: implementation of a backpack safety program with 5th grade students	Shelley Goodgold, 2003	USA	Quasi-experimental	22	10.5 – 11.5 years	To determine the effectiveness of a school-based backpack health promotion program *(Backpack Intelligence)* on children's knowledge about proper use of backpacks, recognising warning signs of improper use, and belief that improper backpack use can cause injury in 5th grade students
22	Back Education Efficacy in Elementary Schoolchildren: A 1-Year Follow-Up Study.	Cardon et al., 2002a	Belgium	Quasi-experimental	696 (347 IG +349 CG)	9 – 11 years	To evaluate the efficacy of a back-education program, on the use of back care principles and prevalence of back and NP in elementary school children
23	Postural Hygiene Program to Prevent Low Back Pain	Méndez and Gómez-Conesa, 2001	Spain	Quasi-experimental	106 (35 IG + 35 Placebo + 35 CG)	9 years	To determine the effectiveness of the Postural Hygiene Program in the prevention of LBP in school children
24	The effects of ergonomically designed school furniture on pupils' attitudes, symptoms and behaviour	Linton et al., 1994	Sweden	Quasi-experimental	67 (46 IG + 21 CG)	10 years	To study the effects of ergonomically designed furniture on sitting posture; comfort; BP, NP and headache symptoms in an applied setting in children

IG: Intervention Group; CG: Control Group; LBP: Low Back Pain; Ex: Exercise; Ed: Education; BP: Back Pain; NP: Neck Pain

Hierarchy of evidence

The NHMRC hierarchy of evidence was used to assess the level of evidence of the eligible studies [70]. The included studies varied in level of evidence due to the different study designs that have been used. Five of the eligible studies were ranked high on the hierarchy of evidence as Level II, because they were RCT's [74-78]. Seven studies were classified as Level III-1 evidence as they were pseudo-randomised controlled studies [80,84-87,88,92,95]. Seven studies were ranked as Level III-2 evidence as the studies were nonrandomised experimental studies [79,83,87,93,94,97]. Six studies were ranked at Level III-3 as they were comparative studies without concurrent controls [81,82,89-91,94].

Methodological appraisal

The selected studies were grouped into RCTs and quasi-experimental studies (non-RCTs). The PEDro scale was used to assess the RCT's (5 studies) and the JBI checklist for quasi-experimental studies (19 studies). The scoring of the studies is reported in Tables 5a and 5b with "y/n" indicating whether the study complied with the criterion (y) or did not comply with the criterion (n). In cases where the criterion was not applicable, such as criterion 3 in the JBI checklist, "n/a" was used. The average score for the RCT's was 6.4/10 and 6.2/9 for the quasi-experimental studies. Candy et al. [77] had the lowest score (4/10) on the PEDro scale and this score was greatly attributed to the fact that the study was not blinded. All RCT's met criteria 2, 4, 10 and 11. However, there was no blinding of the therapists (criterion 6) in any of the RCT's. Ruivo et al. [75] was the only RCT where all the participants and assessors were blinded (criterion 5 and 7 respectively). Hill and Keating [76] met criterion 5 as the subjects, although they knew that they were participating in an intervention (exercise), were not aware of the control conditions. Criterion 3 pertains to concealed allocation of which three studies reported on [75,76,78]. Candy et al. [77] was the only study that did not meet criterion 8 as only approximately 50% of the participants in both groups completed the pain dairies that were allocated to them over the four-week study period [77]. Criterion 9 was only met by one study, Hill and Keating [76], who specifically mentioned that an intention-to-treat analysis was used. Table 5a reports the results for the RCT's as scored on the PEDro scale.

Table 5a: Quality Appraisal of RCT's using the PEDro scale

Author	**Score** (/10)	**Criterion 2**	**Criterion 3**	**Criterion 4**	**Criterion 5**	**Criterion 6**	**Criterion 7**	**Criterion 8**	**Criterion 9**	**Criterion 10**	**Criterion 11**
Ruivo et al., 2017	8	Y	Y	Y	Y	N	Y	Y	N	Y	Y
Hill and Keating, 2015	8	Y	Y	Y	Y	N	N	Y	Y	Y	Y
Candy et al., 2012	4	Y	N	Y	N	N	N	N	N	Y	Y
Fanucchi et al., 2009	7	Y	Y	Y	N	N	Y	Y	N	Y	Y
Jones et al., 2007a	5	Y	N	Y	N	N	N	Y	N	Y	Y

The lowest score on the JBI checklist was 4/9 for two of the 19 quasi-experimental studies [90,91]. All the quasi-experimental studies met criteria 1, 7 and 8. Criterion 3 was not applicable in any of the studies as no other treatment or care was applied during the intervention period. None of the studies, but one [95] had multiple measurements before and after the intervention (criterion 5). Criteria 6, 7, 8 and 9 caused uncertainties for various studies. Any discrepancies or uncertainties were discussed between the authors until consensus was reached. Criteria 6, 7, 8 and 9 were discussed between the authors for the study by Goodgold and Nielsen [90]; criteria 6 and 7 for Bauer and Freivelds [82] and criteria 7, 8 and 9 for Rupesh et al.

[96]. Table 5b reports the results for the quasi-experimental studies as scored on the JBI checklist.

Table 5b: Quality appraisal of quasi-experimental studies using the JBI critical appraisal checklist

Author	Score (/9)	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5	Criterion 6	Criterion 7	Criterion 8	Criterion 9
Rupesh et al., 2016	**6**	Y	Y	N/A	N	N	Y	Y	Y	Y
Ebtisam Ebied, 2015	**6**	Y	N	N/A	Y	N	Y	Y	Y	Y
Syazwan et al., 2011	**7**	Y	Y	N/A	Y	N	Y	Y	Y	Y
Dolphens et al.; 2011	**6**	Y	N	N/A	Y	N	Y	Y	Y	Y
Dockrell et al., 2010	**5**	Y	N	N/A	N	N	Y	Y	Y	Y
Bauer and Freivalds, 2009	**6**	Y	Y	N/A	N	N	Y	Y	Y	Y
Saarni et al., 2009	**7**	Y	Y	N/A	Y	N	Y	Y	Y	Y
Cardon et al., 2007	**7**	Y	Y	N/A	Y	N	Y	Y	Y	Y
Geldhof et al., 2007a	**7**	Y	Y	N/A	Y	N	Y	Y	Y	Y
Geldhof et al., 2007c	**7**	Y	Y	N/A	Y	N	Y	Y	Y	Y
Koskelo et al., 2007	**7**	Y	Y	N/A	Y	N	Y	Y	Y	Y
Geldhof et al., 2006	**7**	Y	Y	N/A	Y	N	Y	Y	Y	Y
Cardon et al., 2004	**6**	Y	Y	N/A	Y	N	N/A	Y	Y	Y
Candy et al., 2004	**7**	Y	Y	N/A	Y	N	Y	Y	Y	Y
Cardon et al., 2002a	**6**	Y	N	N/A	Y	N	Y	Y	Y	Y
Goodgold and Nielsen, 2003	**4**	Y	U	N/A	N	N	N	Y	Y	Y
Goodgold 2003	**4**	Y	U	N/A	N	N	Y	Y	Y	U
Méndez and Gómez-Conesa, 2001	**6**	Y	Y	N/A	Y	N	N	Y	Y	Y
Linton et al.; 1994	**7**	Y	Y	N/A	Y	Y	U	Y	Y	Y

No studies were excluded due to poor methodological quality otherwise it would have decreased the number of included studies considerably.

Description of interventions

The content of the interventions is described in Table 6. Four main themes of intervention were identified (exercise, education, exercise and education and furniture).

Exercise

Only three of the eligible studies investigated the effect of exercise only on spinal health in school children [74,75,78]. The duration of the intervention ranged between eight and 16 weeks and the intervention were carried out at least once a week. The exercises in all three studies included stretches and strengthening of the muscles of either the neck or lower back, with some variations or additions such as diaphragmatic breathing and balance exercises in Fanucchi et al. [78]. In all three studies, the control groups received no intervention.

Education

Education was the intervention of choice in seven of the studies [79,80,82,90-92,97]. The duration of the interventions varied from three minutes to eight weeks. The frequency of the interventions was very different between the studies. Three studies only provided the education session once to the children regardless of how long the intervention was and no mention of reinforcement was made [82,90,92]. The interventions were similar for all the studies regardless of the outcomes and included information about anatomy and biomechanics of the spine, back care and ergonomic principles, postural education and information about schoolbags and how to safely carry and use it. Most of the studies compared the intervention to a control group where no intervention was implemented [79,80,92,97] or reported on pretest-posttest results of a single group [82,90,91].

Exercise and education

Seven of the included studies used a combination of exercise, or physical activity and education as their intervention [76,85,86,88,93,96]. The duration of the intervention of these studies ranged from three weeks to 270 days (approximately nine months). The intervention was the same in the studies by Geldhof et al. [85,86,88] and was similar to the study conducted by Cardon et al. [84] as these studies based their intervention on the work done by Cardon et al. [89,92]. The studies by Geldhof et al. [85,86,88] are follow-up studies with data collected at one year, two years and 6 weeks post intervention respectively. A common theme that stems from the interventions used in these studies is that of maintaining the correct posture; encouraging dynamic sitting or posture and enhancing physical activity or movement. The study by Rupesh et al. [96] focused on education and exercises to prevent or limit NP and was thus slightly different from the other studies that focused on LBP [76,84,93] or a combination of back and neck pain [85,86,88]. Four studies had one control group [76,85,86,88] of which three groups received no intervention [85,86,88] and one received education only [76] as comparison to the intervention. One study used three groups where the intervention (group 1) was compared to education only (group 2) and no intervention (group 3) [84]. In the study by Méndez and Gómez-Conesa, [93] the intervention group was compared to a placebo group and a no intervention group. Rupesh et al. [96] conducted a pretest-posttest study using one group only.

Furniture

Seven studies investigated the effect of adaptations to school furniture on spinal health in children [77,81,83,87;89,94,95]. The duration of the intervention ranged from two weeks to twenty-six months. Four of the seven studies used adjustable tables and/or chairs to promote postural change and support [83,87,89,95]. Two studies by Candy et al. [77,94] introduced a wedge which changed the sitting angle on the usual school chairs of the children. Dockrell et al. [81] made changes to the children's work stations. In the study by Cardon et al. [89] the intervention was already in place as a pilot study that was running in Germany and a control group was randomly selected from a representative sample of children in Belgium. Traditional or conventional furniture was used as control interventions in five studies [77,83,87,89,94,95].

Table 6: Intervention characteristics

Study ID	Intervention	Description of the intervention	Comparison	Duration of intervention	Frequency of intervention	Development of intervention and involvement of stakeholders
1	Exercise	4 Strengthening exercises for rotator cuff, scapula stabilizers, rhomboids, and deep cervical flexor muscles; 3 stretching exercises for pectoralis minor, sternocleidomastoid and levator scapulae	No intervention	16 weeks	Twice a week; during last part of physical education class	The authors
2	Exercise and Education	**Education:** back awareness habits to keep the spine healthy and principles underpinning recommended behaviors; anatomy of the spine, explaining LBP, dynamic vs. static postures, and maintaining correct posture. **Exercise:** 4 exercises to encourage Lx spine FL, Ext and Lat FL through full ranges	Education only	270 days	3 repetitions of each exercise once a day; education was reinforced at each follow up	Parents, teachers and children provided input regarding language and comprehension
3	Furniture	High-density foam wedge measuring 30 cm (depth) × 35 cm (width) ×5 cm (height) with a forward inclination of 10°	No intervention/ traditional chairs	3 weeks	During all classes except for laboratories	Based on work by Wu et al., 1998.
4	Exercise	Warm up, diaphragmatic breathing, core activation in crook lying, bridging and 4-point kneeling, hamstring and lumbar spine stretches, postural alignment, balance exercises, functional exercises, iliopsoas and quadriceps stretches and relaxation	No intervention	8 weeks	1 class/ week; 10–15 min educational session followed by 40–45 min exercise	Based on work by Akuthota et al 2004; Arokoski et al., 2004; Koumantakis et al 2005, Urquhart et al., 2005.
5	Exercise	Pain relieving exercises e.g. 'cat stretch'; Flexibility exercises for hip and knee, e.g. knees to chest and knees to side; Reconditioning exercises e.g. bent knee curl-ups and single leg extension holds; Progressive exercises e.g. single leg and contra-lateral arm extension holds.; Pain relieving home-based exercises	No intervention	8 weeks	2 group sessions/week; 30min/ session	N/R
6	Exercise and Education	**Neck exercises:** isometric exercises, ROM exercises (FL, Ext, Lat FL and rotation of cervical spine), shoulder shrugging; chin tuck; **Posture correction:** postural correction guidelines describing poor posture habits (do not slouch, sit upright) providing instructions in class to correct sitting posture and sit erect	N/A	3 weeks	3 x/ day for 3 weeks, during end of alternate class hours i.e. 5 Repetitions × 3 Sets/ session	N/R
7	Education	Anatomy and structure of spine; scope of the problem; impact of poor posture; ergonomic principles about correct school bag use, handling and arrangement (practical demonstration); principles of good posture and body mechanics; sitting posture, lying, lifting, pushing and pulling; and back exercises	No intervention	1 month	One session/ week; 20min/ session	The author
8	Education	Poster, pamphlet, flyer and CD with short documentary video on ergonomics and exercises to reduce ergonomic risk factors for musculoskeletal pain	No intervention	One class	Twice; 30 min/session	The authors
9	Education	10 guidelines on ''how to make your discs happy'': (1) always keep natural curves of your back, (2) be active, join in sports, (3) place book on a ring binder or inclined desk, (4) when you relax, lie down on your back with legs raised, (5) bend knees, not your back, (6) to lift, stand as close as possible to the object, (7) ask for help in lifting a heavy object, (8) carry an object as close as possible to your body, (9) carry book bag on your back, and (10) book bag should not weigh more than one-tenth of your body weight	No intervention	6 weeks	One session/week; 1hr/ session	Based on work by Cardon et al., 2001; 2002a; 2002b
10	Furniture	**Furniture**: Provision of flat screen monitors and mouse pads, removal of unnecessary items from the desk **Education:** discussed postures, importance of comfort while sitting at the computer, need for frequent breaks	N/A	10 weeks	1h session	Workstation assessment done by authors
11	Education	Standing and walking on treadmill for 3 min. with backpack weight variants of 10, 15, 20% of BM	N/A	6 min (3 min standing still, 3 min walking on treadmill)	Once; 3mins/test	N/R

N/R: Not reported; ROM: Range of Motion; Lx: Lumbar; FL: Flexion; Ext: Extension; Lat FL: Lateral Flexion; N/A: Not applicable; Min: Minutes; BM: Body Mass; IG: Intervention Group; CG: Control Group; 1 Ruivo et al., 2017; 2 Hill and Keating; 2015; 3 Candy et al., 2012; 4 Fanucchhi et al., 2009; 5 Jones et al., 2007; 6 Rupesh et al., 2016; 7 Ebied, 2015; 8 Syazwan et al., 2011; 9 Dolphens et al.; 2011; 10 Dockrell et al., 2010; 11 Bauer and Freivalds, 2009; 12 Saarni et al., 2009; 13 Cardon et al., 2007; 14 Geldhof et al., 2007a; 15 Geldhof et al., 2007b; 16 Koskelo et al., 2007; 17 Geldhof et al., 2006; 18 Cardon et al., 2004; 19 Candy et al., 2004; 20 Goodgold and Nielsen, 2003; 21 Shelley Goodgold, 2003; 22 Cardon et al., 2002a; 23 Méndez and Gómez-Conesa, 2001; 24 Linton et al., 1994

Table 6: Intervention characteristics (continued)

Study ID	Intervention	Description of the intervention	Comparison	Duration of intervention	Frequency of intervention	Development of intervention and involvement of stakeholders
12	Furniture	Adjustable saddle-type chairs with wheels and adjustable desks with comfort curve for the body	Conventional workstations	26 months	During class (Net total exposure time per week= 14.3 h in IG and 17.6 h in the CG)	N/R
13	Exercise and Education	**Education:** anatomy and pathology of the back and basic principles of biomechanical favourable postures during standing, sitting, lying, lifting, pushing and bending, giving movement breaks and using variable work organizations **PA:** lessons on self-management, increasing physical activity levels during physical education lessons based on SPARK; one extra – curricular sport session implemented each week; each class received package of sporting materials to be used during recess and lunch break	Education only and No intervention (2 groups)	6 weeks	1 lesson/ week; 1hr/ lesson (education); 1 session/ week; (duration NR) (PA); (Teachers to continue with repetition and integration of principles in classroom after 6 weeks)	Based on work by Cardon et al., 2004 (education) and Sallis et al., 1997 (PA)
14	Exercise and Education	**Education**: anatomy and pathology of the back and basic principles of biomechanical favorable postures during standing, sitting, lying, lifting, pushing and bending; 10 pictures on back posture principles put up in class on a daily and weekly basis. **Postural Dynamism:** stimulation of dynamic sitting, prevention of prolonged static sitting, decentralized storing places for educational tools, textbooks and schoolbags; active and variable sitting - two pezzi balls, a dynair and a wedge in each classroom; Short movement breaks between the lessons	No intervention	6 weeks	One session/ week; 1hr per session	Based on work by Cardon et al., 2001; Méndez and Gómez-Conesa, 2001; Cardon et al. 2002a; Cardon et al., 2004; Cardon and Balague, 2004
15	Exercise and Education	**Education**: as for study 14 **Postural Dynamism:** as for study 14	No intervention	6 weeks	1 session/ week; 1hr per session	As for study 14
16	Furniture	Adjustable tables (prototype, Martela Oyj, Helsinki, Finland) and adjustable chairs (Salli Saddle Chairs, Easydoing Ltd, Rautalampi, Finland)	Non-adjustable traditional standard horizontal school desk (height 72.8cm) and horizontal chairs (height 42cm)	24 months	During all classes (furniture had wheels to be moved from one class to the next)	N/R
17	Exercise and Education	**Education:** as for study 14 **Postural Dynamism:** as for study 14	No intervention	6 weeks	1 session/ week; 1hr per session thereafter teachers to continue promoting good body mechanics for 2 years	As for study 14
18	Furniture	Information stations; tables with inclinable top (minimum of 16°); stand-at desk; classroom rearranged to encourage variations in daily working routine	Traditional elementary school furniture	1.5 years (comparison done during one class)	During class	Based on work by Breithecker D. Lust auf Schule
19	Furniture	Wedge was used on standard polypropylene school chairs which changed the sitting angle by 10 degrees from back to knee	Traditional furniture	2 weeks	During classes at school	Based on work by Wu et al., 1998.
20	Education	Recognition when backpack is too heavy, identification of desirable backpack features and instruction in the proper way to wear and pack a backpack	N/A	A few months	Once/ During a PE class	Shelley Goodgold (first author)
21	Education	As for study 20	N/A	A few weeks	Once/ First period in the morning	Shelley Goodgold (author)

N/R: Not reported; PA: Physical Activity; N/A: Not applicable; Min: Minutes; SPARK: Sports, Play and Active Recreation for Kids; N/R: Not reported; ROM: Range of Motion; Lx: Lumbar; FL: Flexion; Ext: Extension; Lat FL: Lateral Flexion; Min: Minutes; BM: Body Mass; IG: Intervention Group; CG: Control Group
1 Ruivo et al., 2017; 2 Hill and Keating; 2015; 3 Candy et al., 2012; 4 Fanucchhi et al., 2009; 5 Jones et al., 2007; 6 Rupesh et al., 2016; 7 Ebied, 2015; 8 Syazwan et al., 2011; 9 Dolphens et al.; 2011; 10 Dockrell et al., 2010; 11 Bauer and Freivalds, 2009; 12 Saarni et al., 2009; 13 Cardon et al., 2007; 14 Geldhof et al., 2007a; 15 Geldhof et al., 2007b; 16 Koskelo et al., 2007; 17 Geldhof et al., 2006; 18 Cardon et al., 2004; 19 Candy et al., 2004; 20 Goodgold and Nielsen, 2003; 21 Shelley Goodgold, 2003; 22 Cardon et al., 2002a; 23 Méndez and Gómez-Conesa, 2001; 24 Linton et al., 1994

Table 6: Intervention characteristics (continued)

Study ID	Intervention	Description of the intervention	Comparison	Duration of intervention	Frequency of intervention	Development of intervention and involvement of stakeholders
22	Education	As for study 9	No intervention	6 weeks	6 sessions/ week; 1hr per session	Intervention developed by a team of practitioners, independent of the testers; Health insurance company and local authority were consulted
23	Exercise and Education	**Postural Hygiene Program:** Education phase: The importance of correct postural habits and spinal movements for health, exertion and incorrect posture as a cause of back pain and injuries, muscular training for prevention of dorsal pain, the respiratory system, physiotherapeutic exercises **Training phase:** physiotherapy exercises for the low back that involved positions for sitting, writing, eating, watching television; positions for washing, washing hands, brushing teeth, picking up and carrying objects of varying weights and volume; and strengthening of abdominal and dorsal erector muscles, rocking of the pelvis	Placebo group: participation in academic activities: illness prevention, healthy habits, the spine, the respiratory system, differences among subjects in body development, physical exercise, muscular training, posture and biomechanics in human beings CG: participated in regular unrelated academic activities: underlining texts or drawing diagrams of the lessons, except for those relating to the human body	8 weeks	8 behaviour intervention (education) sessions; 2hr/session 3 physiotherapy sessions; 1hr/session	4 Physiotherapists with more than 5 years of professional experience and specializing in the spine and lumbago
24	Furniture	**Ergonomically designed furniture:** desks with slanted tops and chairs with curved seats; chairs provide back support when listening and when working; curved seat encourages student to sit both forward and back, enhancing lordotic curve; desks and chairs are elevated to avoid teachers bending down when helping students	**Traditional furniture:** desk with flat top (parallel to the floor) and a detached chair with straight back and seat placed at 90° angle	6 months	During class for 6 months	According to Mandal (1982)

N/R: Not reported; ROM: Range of Motion; Lx: Lumbar; FL: Flexion; Ext: Extension; Lat FL: Lateral Flexion; N/A: Not applicable; Min: Minutes; BM: Body Mass; IG: Intervention Group; CG: Control Group; 1 Ruivo et al., 2017; 2 Hill and Keating; 2015; 3 Candy et al., 2012; 4 Fanucchhi et al., 2009; 5 Jones et al., 2007; 6 Rupesh et al., 2016; 7 Ebied, 2015; 8 Syazwan et al., 2011; 9 Dolphens et al.; 2011; 10 Dockrell et al., 2010; 11 Bauer and Freivalds, 2009; 12 Saarni et al., 2009; 13 Cardon et al., 2007; 14 Geldhof et al., 2007a; 15 Geldhof et al., 2007b; 16 Koskelo et al., 2007; 17 Geldhof et al., 2006; 18 Cardon et al., 2004; 19 Candy et al., 2004; 20 Goodgold and Nielsen, 2003; 21 Shelley Goodgold, 2003; 22 Cardon et al., 2002a; 23 Méndez and Gómez-Conesa, 2001; 24 Linton et al., 1994

Spinal health outcomes and outcome measurement tools

The outcomes pertaining to spinal health that were measured, as defined for this review (see Methods section: Inclusion and exclusion criteria for search strategy A), were extracted and are described in Table 7.

The description of the spinal health outcomes varied in terms of area of pain or discomfort, i.e. back pain (lower/upper back), back and/or neck pain and neck pain. Pain prevalence (neck, back or neck and back) was the most common outcome measure used in 17 of the studies [75,76,78-80,84-95]. Seven of the 24 studies also measured spinal well-being [74,78,81; 91,92,95,96].

Various outcome measurement tools were used of which questionnaires were the most common. Pain intensity was measured using various scales i.e. VAS, NRS, 10-point scale, BORG –CR10 scale and a 5-point scale. Pain prevalence was determined by means of questionnaires related to neck and or back pain. Two studies measured well-being with specific outcome measuring tools i.e. the Mental Health Inventory-5 [78] and the Neck Disability Index (Rupesh et al., 2016). The other studies which measured well-being, used questionnaires in more descriptive ways e.g. if the child felt tired or if the pain affected their participation in sport / physical activity / school [74,78,81,90,91,95,97].

The pain recall period also varied between studies of which eight studies [76; 80; 84-86,88,89,92] asked about pain in the last week and seven enquired about current pain symptoms [77,78,81-83,94,97]. One study, had three pain recall periods i.e. current, the past month and the past three months [78]. Another study recalled pain symptoms up to six months [83] and one study enquired about pain in the past two months [87].

The remaining six studies did not specify the pain recall period [79,90,91,93,95,96].

Table 7: Description of the spinal health outcomes

Study ID	Description of spinal health outcome	Spinal health outcome	Outcome measurement tool	Pain recall period
1	NP	NP prevalence	Questionnaire: yes/ no	1 month
2	• Pain (lifetime first episode, or in past week) between T12 and S1 and • Its effects on activity, school and sports attendance	• LBP prevalence LBP duration • Well-being	**MySpine survey** • 1-7 days [later dichotomised to shorter (1-2days)/longer (≥ 3days) periods] • Seeing a health care professional or absence from school/sports	1 Week
3	Any type of BP, whether the pain was frequent, limited activities, or caused participant to seek medical advice	Pain intensity	NRS 0 – 10	Current (in the morning and evening of school days)
4	• Pain or discomfort in the lower parts of the back, excluding pain due to serious spinal pathologies or deformities. • How the child felt about school and life in general	• Pain intensity • Prevalence of LBP/discomfort • Well-being	• 10cm VAS plus faces • Questionnaire • MHI-5 and two face scales	Current, 1 month, 3 months
5	• Recurrent NSLBP • Well-being: school and sports attendance related to NSLBP	• Pain frequency • Pain intensity • Well-being	**One-week diary** • Number of days NSLBP was experienced • 10-point scale • Participation/ absence from school/sport	NR
6	• NP with VAS scoring between 2 to 6 • NDI score between 20 to 25	• NP intensity • Well-being	• VAS • NDI	NR
7	School bag associated pain	Pain intensity	**Wong-Baker faces pain rating scale:** 0 – 10 (6 faces)	Current
8	• Musculoskeletal pain in the neck, shoulder, upper back, lower back- area lasting for 1 week or 1 month	• Area • Pain prevalence	**Standardized Nordic Body Map Questionnaire** • Body diagram consisting of 9 body parts • Questions regarding 1 month or 7 days of musculoskeletal pain	NR
9	BP or NP or discomfort, continuous or recurrent, but not due to fatigue related to a single exercise	BP and NP Prevalence	**Questionnaire:** questions related to BP and NP	1 Week
10	• Body discomfort (well-being)	• Pain intensity • Area of discomfort	• VAS (10cm line) • BDC	Current
11	• Participants' perception of pain and exertion in the shoulder, middle and lower back areas and of the whole body	• Exertion • Intensity • Area	• Borg-RPE • Borg-CR10 Scale	Current
12	• Musculoskeletal strain: how strained or exhausted the participant was feeling at the time in the specified body areas (neck–shoulder, upper and low back) • Pain defined as smart, ache or distress in the specified body areas (neck–shoulder, upper and low back)	**Musculoskeletal strain** • Pain intensity • Area **Musculoskeletal pain** • Pain intensity • Area	• Modified Borg CR-10 Scale • Body chart • 0–100 mm VAS • Body chart	Current, 6months
13	BP or discomfort, continuous or recurrent, but not due to fatigue related to a single exercise	BP prevalence	Questionnaire	1 Week

NSLBP: Non-Specific Low Back Pain; VAS: Visual Analogue Scale; NP: Neck Pain; BP: Back Pain; MHI: Mental Health Inventory; NRS: Numerical Rating Scale; Borg CR-10 Scale: Borg Category Ratio-10 Scale; Borg-RPE; BDC: Body Discomfort Chart; NDI: Neck Disability Index; 1 Ruivo et al., 2017; 2 Hill and Keating; 2015; 3 Candy et al., 2012; 4 Fanucchhi et al., 2009; 5 Jones et al., 2007; 6 Rupesh et al., 2016; 7 Ebied, 2015; 8 Syazwan et al., 2011; 9 Dolphens et al.; 2011; 10 Dockrell et al., 2010; 11 Bauer and Freivalds, 2009; 12 Saarni et al., 2009; 13 Cardon et al., 2007; 14 Geldhof et al., 2007a; 15 Geldhof et al., 2007b; 16 Koskelo et al., 2007; 17 Geldhof et al., 2006; 18 Cardon et al., 2004; 19 Candy et al., 2004; 20 Goodgold and Nielsen, 2003; 21 Shelley Goodgold, 2003; 22 Cardon et al., 2002a; 23 Méndez and Gómez-Conesa, 2001; 24 Linton et al., 1994

Table 7: Description of spinal health outcomes (continued)

Study ID	Description of spinal health outcome	Spinal health outcome	Outcome measurement tool	Pain recall period
14	BP and NP	BP and NP Prevalence	Questionnaire: questions related to BP and NP	1 week
15	BP and NP	BP and NP Prevalence	Questionnaire: questions related to BP and NP	1 week
16	Self-reported LBP, neck-shoulder pain (headache) in past 2 months	Neck-shoulder and LBP prevalence	Questionnaire (yes/no answers)	2 months
17	• BP and NP within last week	• BP and NP prevalence • BP and NP intensity • BP and NP frequency	**Questionnaire** • Intensity: 5-point-scale (a little bit pain, a bit pain, modest pain, much pain, very much pain) • Frequency: 4-point-scale (once, several times, frequently, continuous)	1 Week
18	BP or NP or discomfort, continuous or recurrent, but not due to fatigue related to a single exercise	• NP and BP prevalence • Well-being	**Questionnaire** • Ever having visited a doctor, being treated for BP/NP or using medication for BP/NP	1 Week
19	• Pain between occiput and buttock crease	• BP intensity • BP frequency	**Pain diaries:** • NRS • y/n question	Current (twice daily)
20	• BP • Perception that improper backpack carriage can cause BP	• BP prevalence BP recurrence • Well-being	**Questionnaire** • History of BP and recurrence • Belief that improper backpack use can cause injury	NR
21	• Back, neck (or shoulder) pain when wearing backpack • Paraesthesia down arm, red marks on shoulders, postural changes	• BP prevalence • Well-being	**Questionnaire:** questions related to back pain, paraesthesia, red marks under straps, changing of posture when carrying backpack, struggling with donning/doffing	NR
22	As for study 9	BP and NP prevalence	**Questionnaire:** questions related to BP and NP	1 Week
23	• LBP • Back problems that require medical treatment after completion of program	• LBP prevalence • Well-being	Independent health check conducted by local school health services	Not specified
24	• BP, NP (and headache) • Feeling tired during school	• BP and NP Prevalence • Well-being (feeling tired) • Pain frequency	• Questionnaire (yes/no to whether they had back, neck pain or headache and if they felt tired) • VAS (very seldom/ one per term, and very often/every day**)**	Not specified

NSLBP: Non-Specific Low Back Pain; VAS: Visual Analogue Scale; NP: Neck Pain; BP: Back Pain; MHI: Mental Health Inventory; NRS: Numerical Rating Scale; Borg CR-10 Scale: Borg Category Ratio-10 Scale; Borg-RPE; BDC: Body Discomfort Chart; NDI: Neck Disability Index

1 Ruivo et al., 2017; 2 Hill and Keating; 2015; 3 Candy et al., 2012; 4 Fanucchhi et al., 2009; 5 Jones et al., 2007; 6 Rupesh et al., 2016; 7 Ebied, 2015; 8 Syazwan et al., 2011; 9 Dolphens et al.; 2011; 10 Dockrell et al., 2010; 11 Bauer and Freivalds, 2009; 12 Saarni et al., 2009; 13 Cardon et al., 2007; 14 Geldhof et al., 2007a; 15 Geldhof et al., 2007b; 16 Koskelo et al., 2007; 17 Geldhof et al., 2006; 18 Cardon et al., 2004; 19 Candy et al., 2004; 20 Goodgold and Nielsen, 2003; 21 Shelley Goodgold, 2003; 22 Cardon et al., 2002a; 23 Méndez and Gómez-Conesa, 2001; 24 Linton et al., 1994

Effectiveness of the interventions

The results of the four main interventions (exercise, education, exercise and education and furniture) are presented in four tables (Tables 8a – 8d); each intervention separately. Baseline data, follow-up data and the statistical interpretation of the effectiveness of the interventions at each follow-up period, are presented in the tables.

Exercise

Table 8a reports on the effectiveness of exercise only. Spinal health outcomes such as NP and LBP prevalence, LBP intensity and frequency as well as spinal well-being were included. The longest follow-up period for exercise was three months and therefore all the results were interpreted as effectiveness in the short-term.

1) Effect on spinal health

Two studies reported a significant decrease in BP intensity after the application of exercise [74,78]. Exercise also had a positive effect on NP prevalence [75] and LBP frequency [74], although not significant.

2) Effect on spinal well-being

Jones et al. [74] demonstrated that exercise significantly improved the spinal well-being in terms of participation in sport or physical activity, however reported no change in the absence from school. Fanucchi et al. [78] reported no significant changes in the spinal well-being of the children.

Table 8a: The effect of exercise on spinal health

Study ID	Baseline	1st follow-up	Description	Statistics	2nd follow-up	Description	Statistics
1	**NP prevalence** IG: 34 (41%); CG: 22 (48%)	Post intervention	Decrease in both groups **(significance NR)**	**NP prevalence** IG: 14 (18%); CG: 12 (31%)	N/A	N/A	N/A
4	**LBP intensity** **Past month** Mean (SD) IG = 5.0(2.8); CG = 4.0(2.9)	Post - intervention	Decrease in both groups; Significant difference between groups	**LBP intensity** **Past month** Mean (SD) IG = 2.3(2.6); CG = 3.3(2.7) **Between groups** Mean (95% CI) -2.2 (-3.5 to -1.0)	3 months post-intervention	Decrease in both groups compared to baseline; significant difference between groups	**LBP intensity** **Past month** Mean (SD) IG = 1.7 (2.8); CG = 2.6(2.4) Between groups Mean (95% CI) -2.0 (-3.5 to -0.5)
	Current Mean (SD) IG = 2.4(3.0); CG = 2.6(3.2)		Decrease in IG, no change in CG; no significant difference between groups	**Current** Mean (SD) IG = 1.1 (2.1); CG = 2.6(2.9) **Between groups** Mean (95% CI) -1.2 (-2.6 to 0.2)		Decrease in both groups compared to baseline; no significant difference between groups	**Current** Mean (SD) IG = 1.5(2.7); CG = 1.5(2.2) **Between groups** Mean (95% CI) 0.3 (-1.3 to 1.9)
	3-month prevalence NR		More participants in CG reported on pain in last 3 months	**3 -month prevalence** IG = 26 (67%); CG = 29 (91%)		Decrease in IG and slight decrease in CG compared to post-intervention	**3-month prevalence** IG = 16 (42%); CG = 26 (81%)
			Absolute risk reduction of 24% in IG compared with CG	**Absolute risk reduction** **Between groups** Mean (95% CI) IG relative to CG = 0.24 (0.04 - 0.41)		Absolute risk reduction of 40% in IG compared with CG	**Absolute risk reduction** **Between groups** Mean (95% CI) IG relative to CG = 0.40 (0.18 - 0.57)
	Well-being **MHI** Mean (SD) IG = 22 (4); CG = 21 (4)		Slight increase in both groups; no significant difference between groups	**Well-being** **MHI** Mean (SD) IG = 23 (4); CG = 23 (3) **Between groups** Mean (95% CI) -1 (-3 to 1)		Slight increase in both groups compared to baseline; no significant difference between groups No change in IG and slight decrease in CG (similar to baseline results); no significant difference between groups	**Well-being** **MHI** Mean (SD) IG = 24 (5); CG = 22 (4) **Between groups** Mean (95% CI) 1 (-1 to 3)
	School Mean (SD) IG = 5.1 (1.0); CG = 4.8 (1.1)		Slight decrease in IG and slight increase in CG; no significant difference between groups	**School** Mean (SD) IG = 4.9 (1.1); CG = 4.9 (1.1) **Between groups** Mean (95% CI) -0.3 (-0.7 to 0.1)		Slight decrease in IG, slight increase in CG compared to baseline; no significant difference between groups	**School** Mean (SD) IG = 5.1 (1.0); CG = 4.7 (1.2) **Between groups** Mean (95% CI) (-0.4 to 0.6)
	General Mean (SD) IG = 5.1 (0.9); CG = 4.9 (1.2)		Slight decrease in IG and slight increase in CG; no significant differences between groups	**General** Mean (SD) IG = 5.0 (1.2); CG = 5.1 (0.9) **Between groups** Mean (95% CI) -0.3 (-0.8 to 0.2)			**General** Mean (SD) IG = 5.0 (1.2); CG = 5.0 (1.1) **Between groups** Mean (95% CI); -0.2 (-0.8 to 0.4)

NP: Neck Pain; NR: Not Reported; IG: Intervention Group; CG: Control Group; NSLBP: Non-specific Low Back Pain; NS: Not significant; PA: Physical Activity; N/A: Not Applicable
1 Ruivo et al., 2017; 2 Hill and Keating; 2015; 3 Candy et al., 2012; 4 Fanucchhi et al., 2009; 5 Jones et al., 2007; 6 Rupesh et al., 2016; 7 Ebied, 2015; 8 Syazwan et al., 2011; 9 Dolphens et al.; 2011; 10 Dockrell et al., 2010; 11 Bauer and Freivalds, 2009; 12 Saarni et al., 2009; 13 Cardon et al., 2007; 14 Geldhof et al., 2007a; 15 Geldhof et al., 2007b; 16 Koskelo et al., 2007; 17 Geldhof et al., 2006; 18 Cardon et al., 2004; 19 Candy et al., 2004; 20 Goodgold and Nielsen, 2003; 21 Shelley Goodgold, 2003; 22 Cardon et al., 2002a; 23 Méndez and Gómez-Conesa, 2001; 24 Linton et al., 1994

Table 8a: The effect of exercise on spinal health (continued)

Study ID	Baseline	1st follow-up	Description	Statistics	2nd follow-up	Description	Statistics
5	**NSLBP** **Frequency** Mean (SD) IG = 3.4(1.5); CG = 3.5(1.8)	1 week post-intervention	Decrease in IG and increase in CG; no significant difference between groups	**NSLBP** **Frequency** Mean (SD): IG = 2.9(1.3); CG = 3.7(1.2) Between groups: p = 0.036, Effect size = 0.39(NS)	N/A	N/A	
	Intensity Mean (SD) IG = 6.5(1.2); CG = 5.3(2.3)		Significant decrease in IG, and slight increase in CG; significant difference between groups	**Intensity** Mean (SD**)** IG= 3.7(1.3), p<0.01; CG = 6.0(1.5), p>0.01 Between groups: P = 0.001, Effect size = 1.47 (significant)			
	Well-being **Absence from sport/PA:** Mean (SD) IG = 1.1(1.1); CG = 0.7(1.0);		Significant decrease in IG and slight increase in CG; significant difference between group	**Well-being** **Absence from sport/PA** Mean (SD) IG = 0.2(0.5), p<0.01; CG = 0.8(0.9), p>0.01 Between groups: p = 0.001, Effect size = 0.99 (significant)			
	Weekly participation in sport Mean (SD) IG = 2.6(1.7); CG = 3.1(2.2)		Significant increase in IG; No change in CG; significant difference between groups	**Weekly participation in sport** Mean (SD) IG = 4.6(1.0), p <0.01; CG = 3.1(2.0), p >0.01 Between groups: p = 0.001, Effect size = 1.03 (significant)			
	Absence from school Mean (SD) IG = 0.1(0.2); CG = 0.1(0.3)		No change in both groups	**Absence from school** Mean (SD) IG = 0.1(0.1), p >0.01; CG = 0.1(0.3), p>0.01 Between groups: p = 0.661, Effect size = 0.27 (NS)			

NSLBP: Non-specific Low Back Pain; IG: Intervention group; CG: Control Group; NR: Not Reported; MHI: Mental Health Inventory; PA: Physical Activity; N/A: Not Applicable
1 Ruivo et al., 2017; 2 Hill and Keating; 2015; 3 Candy et al., 2012; 4 Fanucchhi et al., 2009; 5 Jones et al., 2007; 6 Rupesh et al., 2016; 7 Ebied, 2015; 8 Syazwan et al., 2011; 9 Dolphens et al.; 2011; 10 Dockrell et al., 2010; 11 Bauer and Freivalds, 2009; 12 Saarni et al., 2009; 13 Cardon et al., 2007; 14 Geldhof et al., 2007a; 15 Geldhof et al., 2007b; 16 Koskelo et al., 2007; 17 Geldhof et al., 2006; 18 Cardon et al., 2004; 19 Candy et al., 2004; 20 Goodgold and Nielsen, 2003; 21 Shelley Goodgold, 2003; 22 Cardon et al., 2002a; 23 Méndez and Gómez-Conesa, 2001; 24 Linton et al., 1994

Education

Table 8b reports on the effectiveness of education only. Spinal health outcomes included NP, LBP, upper back pain (UBP) and spinal pain prevalence, spinal pain intensity and spinal well-being. Most of the studies evaluated short term effectiveness of the intervention [79,90,91,97] and two studies looked at short and long-term effectiveness of the intervention [80,92].

1) Effect on spinal health

BP intensity [97] and prevalence [80,92] and NP/UBP prevalence [79] significantly improved post intervention. Cardon et al. [92] reported only an improvement in spinal pain prevalence whereas Syazwan et al., [79] and Goodgold, [91] found no change in either LBP or spinal pain prevalence respectively. Dolphens et al. [80] showed that the positive effects of education on BP prevalence were long-lasting up until a year, but the effect could not be sustained up to eight years post intervention.

2) Effect on spinal well-being

After being educated on the proper use of backpacks, more children believed that the improper use of schoolbags could lead to injury [90] and more children could recognise the warning signs of improper schoolbag use [91]. Bauer and Freivalds [82] found a significant increase in perceived pain intensity and discomfort when the children wore schoolbag loads more than 10% of their body weight.

Table 8b: The effect of education only on spinal health

Study ID	Baseline	1st follow-up	Description	Statistics	2nd follow-up	Description	Statistics
7	Pain intensity n (%) **No hurt** IG: 3 (6); CG: 5 (10)	1-week post-intervention	Increase in IG, no change in CG; Significant difference between groups	Pain intensity n (%) **No hurt** IG: 14 (28); CG: 5 (10); p < 0.000	3 months post-intervention	Increase in IG, slight decrease in CG; Significant difference between groups	Pain intensity n (%) **No hurt** IG: 21 (42); CG: 4 (8); p < 0.05
	Hurts just a little bit IG: 14 (28); CG: 16 (32)		Increase in IG, decrease in CG; Significant difference between groups	**Hurts just a little bit** IG: 32 (64); CG: 13 (26); p < 0.000		Increase in IG, decrease in CG; Significant difference between groups	**Hurts just a little bit** IG: 18 (36); CG: 14 (28); p < 0.05
	Hurts a little more IG: 9 (18); CG:9 (18)		Decrease in IG, increase in CG; Significant difference between groups	**Hurts a little more** IG: 4 (8); CG:11 (22); p < 0.000		Decrease in IG, increase in CG; Significant difference between groups	**Hurts a little more** IG: 5 (10); CG: 11 (22); p < 0.05
	Hurts even more IG: 16 (32) ;CG: 12 (24)		Decrease in IG, slight decrease in CG; Significant difference between groups	**Hurts even more** IG: 0 (0) ;CG: 11 (22); p < 0.000		Decrease in IG, slight decrease in CG; Significant difference between groups	**Hurts even more** IG: 5 (10); CG: 11 (22); p < 0.05
	Hurts a whole lot IG: 7 (14); CG: 4 (8)		Decrease in IG, increase in CG; Significant difference between groups	**Hurts a whole lot** IG: 0 (0); CG: 6 (12); p < 0.000		Decrease in IG, increase in CG; Significant difference between groups	**Hurts a whole lot** IG: 1 (2); CG: 6 (12); p < 0.05
	Hurts at worst IG: 1 (2); CG: 4 (8)		Decrease in IG, no change in CG; Significant difference between groups	**Hurts at worst** IG: 0 (0); CG: 4 (8); p < 0.000		Decrease in IG, no change in CG; Significant difference between groups	**Hurts at worst** IG: 0 (0); CG: 4 (8); p< 0.05
8	Pain prevalence n(%) **Neck** IG = 15 (19.2); CG = 26 (34.7)	1 month post 1st intervention	Significant decrease in IG and increase in CG	Pain prevalence n(%) **Neck** IG = 13 (16.9), p< 0.05 (within group) CG = 30 (40.0)	1 month post 2nd intervention	Significant decrease in IG and decrease in CG compared to baseline Significant decrease in CG compared to 1ST follow-up	Pain prevalence n(%) **Neck** IG = 12 (15.8), p<0.05 (within group); CG = 22 (29.3) CG = 22 (29.3); p<0.05
	Upper back IG = 8 (10.3); CG = 13 (17.3)		No change in IG and slight increase in CG	**Upper back** IG = 8 (10.3), CG = 14 (18.7)		Significant decrease in IG and increase in CG compared to baseline	**Upper back** IG = 3 (4.1), p<0.05 (within group) CG = 22 (29.3)
	Lower back IG = 8 (10.3); CG =11 (14.7)		No change in IG and increase in CG	**Lower back** IG = 8 (10.3), CG = 16 (21.3)		No change in IG and increase in CG compared to baseline	**Lower back** IG = 8 (10.3), CG = 15 (20.0)

NP: Neck Pain; BP: Back Pain; IG: Intervention group; CG: Control Group

1 Ruivo et al., 2017; 2 Hill and Keating; 2015; 3 Candy et al., 2012; 4 Fanucchhi et al., 2009; 5 Jones et al., 2007; 6 Rupesh et al., 2016; 7 Ebied, 2015; 8 Syazwan et al., 2011; 9 Dolphens et al.; 2011; 10 Dockrell et al., 2010; 11 Bauer and Freivalds, 2009; 12 Saarni et al., 2009; 13 Cardon et al., 2007; 14 Geldhof et al., 2007a; 15 Geldhof et al., 2007b; 16 Koskelo et al., 2007; 17 Geldhof et al., 2006; 18 Cardon et al., 2004; 19 Candy et al., 2004; 20 Goodgold and Nielsen, 2003; 21 Shelley Goodgold, 2003; 22 Cardon et al., 2002a; 23 Méndez and Gómez-Conesa, 2001; 24 Linton et al., 1994

Table 8b: The effect of education only on spinal health (continued)

Study ID	Baseline	1st follow-up	Description	Statistics
11	**Perceived exertion** (0% BM) NR	Post-intervention	Significant, but similar change in exertion between all load levels (therefore, one load limit is not better than the other)	**Perceived exertion (standing and walking)** 0 – 10%: $p < 0.05$ 10 – 15%: $p < 0.05$ 15 – 20%: $p < 0.05$
	Perceived pain intensity (0% BM) NR		Significant increase in pain intensity between load levels 10 – 15% and 15 – 20%, but no significant change between 0 – 10%	**Perceived pain intensity (standing and walking)** 0 – 10%: NS changes, except for shoulder (while standing) 10 – 15%: average increase in scores = 245%; $p < 0.05$ 15 – 20%: average increase in scores = 176%; $p < 0.05$
20	**BP prevalence (%):** 25	Post-intervention	**BP prevalence:** NR	**BP prevalence:** NR
	Recurrence of BP (%): 49(of those with BP)		**Recurrence of BP:** NR	**Recurrence of BP:** NR
	Discomfort while carrying backpack (%): 46		**Discomfort while carrying backpack:** NR	**Discomfort while carrying backpack:** NR
	Believe that improper backpack use could cause injury (%) 66 (of total group); 73% students with hx of BP		Increase in total group Significant gender difference: more girls than boys believed improper backpack use could cause injury	**Believe that improper backpack use could cause injury (%)** 72 (of total group) 88% girls vs 59% boys; p =< 0.000
21	**Back pain prevalence (%): 73**	Post-intervention	No change in back pain prevalence compared to baseline	**Back pain prevalence (%): 73**
	Well-being (warning signs) **Struggling with donning/doffing (%): 86**		Decrease in donning/doffing compared to baseline	**Well-being (warning signs)** **Struggling with donning/doffing (%): 64**
	Paraesthesia (%): 36		Decrease in paraesthesia compared to baseline	**Paraesthesia (%): 27**
	Postural changes (%): 82		Decrease in postural changes compared to baseline	**Postural changes (%): 68**
	Red marks under straps (%): 45		Decrease in red marks under straps compared to baseline	**Red marks under straps (%): 27**
	Believe that improper backpack use could cause injury **NR**			**Believe that improper backpack use could cause injury (%) 77%**

BDC: Body Discomfort Chart; VAS: Visual Analogue Scale; BP: Back Pain; NR: Not Reported; LBP: Low Back Pain; NP: Neck Pain; Hx: History;
1 Ruivo et al., 2017; 2 Hill and Keating; 2015; 3 Candy et al., 2012; 4 Fanucchhi et al., 2009; 5 Jones et al., 2007; 6 Rupesh et al., 2016; 7 Ebied, 2015; 8 Syazwan et al., 2011; 9 Dolphens et al.; 2011; 10 Dockrell et al., 2010; 11 Bauer and Freivalds, 2009; 12 Saarni et al., 2009; 13 Cardon et al., 2007; 14 Geldhof et al., 2007a; 15 Geldhof et al., 2007b; 16 Koskelo et al., 2007; 17 Geldhof et al., 2006; 18 Cardon et al., 2004; 19 Candy et al., 2004; 20 Goodgold and Nielsen, 2003; 21 Shelley Goodgold, 2003; 22 Cardon et al., 2002a; 23 Méndez and Gómez-Conesa, 2001; 24 Linton et al., 1994

Table 8b: The effect of education only on spinal health (continued)

Study ID	Baseline	1st follow-up	Description	Statistics	2nd follow-up	Description	Statistics	3rd follow-up	Description	Statistics
9	**BP and/or NP prevalence** (%) IG = 34.4; CG = 19.4	1-week post intervention	Decrease in IG and slight increase in CG; significant difference between groups	**BP and/or NP prevalence** (%) IG = 29.8; CG = 20.6; $p < 0.001$	1 year	Decrease in both groups compared to baseline; significant difference between groups	**BP and/or NP prevalence** (%) IG = 27.7; CG = 16.7; $p<0.001$	8 years	Increase in both groups compared to baseline, significant difference between groups Prevalence significantly higher for both groups compared to baseline and all other follow-ups	**BP and/or NP prevalence** (%) IG = 54.2; CG = 41.8; $p < 0.001$ $p < 0.001$
22	**BP and NP prevalence** n (%) IG = 111 (31.9) CG = 98 (28.1)	1-week post intervention	Decrease in both groups	**BP and NP prevalence** n (%) IG = 93 (26.8); CG = 73 (20.9)	3 months	Decrease in both groups compared to baseline	**BP and NP prevalence** n (%) IG = 82 (24.0) CG = 93(26.6)	1 year	Decrease in both groups compared to baseline; significant difference between groups	**BP and NP prevalence** n (%) IG = 74 (23.3); CG = 84 (29.9); $p < 0.05$

BDC: Body Discomfort Chart; VAS: Visual Analogue Scale; BP: Back Pain; NR: Not Reported; LBP: Low Back Pain; NP: Neck Pain; Hx: History;
1 Ruivo et al., 2017; 2 Hill and Keating; 2015; 3 Candy et al., 2012; 4 Fanucchhi et al., 2009; 5 Jones et al., 2007; 6 Rupesh et al., 2016; 7 Ebied, 2015; 8 Syazwan et al., 2011; 9 Dolphens et al.; 2011; 10 Dockrell et al., 2010; 11 Bauer and Freivalds, 2009; 12 Saarni et al., 2009; 13 Cardon et al., 2007; 14 Geldhof et al., 2007a; 15 Geldhof et al., 2007b; 16 Koskelo et al., 2007; 17 Geldhof et al., 2006; 18 Cardon et al., 2004; 19 Candy et al., 2004; 20 Goodgold and Nielsen, 2003; 21 Shelley Goodgold, 2003; 22 Cardon et al., 2002a; 23 Méndez and Gómez-Conesa, 2001; 24 Linton et al., 1994

Exercise and education

Table 8c reports on the effectiveness of exercise and education combined. Spinal health outcomes included LBP, BP or NP prevalence; lifetime first episode; pain duration; NP and BP intensity and spinal well-being. This intervention had follow-up periods of up to two years post-intervention and results could therefore be divided into short and long-term effectiveness. The study by Hill and Keating, [76] had numerous follow-up periods i.e. day 7 (first follow-up), day 21, 49, 105, 161 and day 270. Only the first and last follow-ups were recorded in the table to correlate with the follow-up periods of the other studies.

1) Effect on spinal health

The combination of exercise and education resulted in a significant decrease in NP prevalence [97]; BP prevalence [76] and lifetime first episode of LBP [76]. Six studies reported a non-significant improvement in spinal pain intensity [88], spinal pain prevalence [85,86,88] and spinal pain frequency [88] as well as BP prevalence [76,84,93]. However, Hill and Keating [76] reported a negative effect of the intervention on BP duration.

2) Effect on spinal well-being

Exercise and education resulted in a significant improvement in the NDI scores, indicating a positive effect on the well-being of the children [96]. Méndez and Gómez-Conesa [93] reported an increase in required medical intervention in the control group after the implementation of a postural hygiene program, with no children in the intervention group requiring medical intervention. In the study by Hill and Keating [76], both groups had the same outcome in terms of school attendance, participation in sport and visiting a healthcare professional and since no baseline data was reported, no conclusions can be drawn.

Table 8c: The effect of exercise/physical activity and education on spinal health

Study ID	Baseline	1st follow-up	Description	Statistics	2nd follow-up	Description	Statistics
2	***LBP Prevalence** % IG= 46%, CG= 47% (*pain ever experienced and current pain)	day 7	Decrease in both groups	**LBP prevalence** % IG =23%, CG= 33%	day 270 total reports over 270 days	Decrease in both groups compared to baseline; Decrease in both groups compared to baseline; Significant reduction in the risk of LBP episodes for IG	**LBP prevalence** % IG = 16%, CG = 24% **Total during study:** IG: 20%, CG: 28% OR=0.54; 95% CI: 0.39 – 0.74; p <0.001
	Lifetime 1st episode N/A			**Lifetime 1st episode** % IG =10%, CG =15%	day 270 total reports over 270 days	Decrease in both groups compared to 1st follow-up Increase in both groups compared to 1st follow-up; Significant reduction in the risk of lifetime 1st episode for IG	**Lifetime 1st episode** %: IG = 5%, CG = 13% **Total during study:** IG: 34%, CG: 47% OR=0.60; 95% CI: 0.39 – 0.91; p= 0.02
	Pain duration NR			**Pain duration** NR	total reports over 270 days	No significant difference between groups	**Pain duration** % (for total duration of study) **Shorter episode:** IG = 62%, CG = 72% **Longer episode:** IG = 38%, CG = 28% OR=1.27; 95% CI: 0.88 - 1.86; p=0.20
	Well-being **Participation in school sports** NR			**Well-being** **Participation in school sports** NR	total reports over 270 days	No significant difference between groups	**Well-being** **Participation in school sports** **Total during study:** IG = 9%, CG = 9% OR=1.03; 95% CI=0.49 - 2.18; p=0.941
	Absence from school N/R			**Absence from school:** N/R	total reports over 270 days	No significant difference between groups	**Absence from school:** IG = 5%, CG = 5% OR 0.87; 95% CI: 0.40 - 1.86; p=0.710
	Visits to health care practitioner: N/R			**Visits to health care practitioner** N/R		No significant difference between groups	**Visits to health care practitioner:** IG = 9%, CG = 9% OR 0.8; 95% CI: 0.36 - 1.80; p= 0.593
6	**Well-being (NDI)** Mean (SD) IG: 21.80 (1.44)	Post – intervention	Significant decrease in NDI scores	**Well-being (NDI)** Mean (SD) IG: 19.76 (1.89); 95% CI = 0.36 – 1.29, p = 0.00	N/A	N/A	N/A
	NP intensity (VAS) Mean (SD) IG: 4.80 (1.31)		Significant decrease in VAS scores	**NP intensity (VAS)** Mean (SD) IG: 2.80 (1.95) 95% CI = 0.18 – 1.65, p = 0.00			

BP: Back Pain; Ed: Education; PA: Physical Activity; NP: Neck Pain; LBP: Low Back Pain; IG: Intervention group; CG: Control Group; NR: Not Reported; N/A: Not Applicable
1 Ruivo et al., 2017; 2 Hill and Keating; 2015; 3 Candy et al., 2012; 4 Fanucchhi et al., 2009; 5 Jones et al., 2007; 6 Rupesh et al., 2016; 7 Ebied, 2015; 8 Syazwan et al., 2011; 9 Dolphens et al.; 2011; 10 Dockrell et al., 2010; 11 Bauer and Freivalds, 2009; 12 Saarni et al., 2009; 13 Cardon et al., 2007; 14 Geldhof et al., 2007a; 15 Geldhof et al., 2007b; 16 Koskelo et al., 2007; 17 Geldhof et al., 2006; 18 Cardon et al., 2004; 19 Candy et al., 2004; 20 Goodgold and Nielsen, 2003; 21 Shelley Goodgold, 2003; 22 Cardon et al., 2002a; 23 Méndez and Gómez-Conesa, 2001; 24 Linton et al., 1994

Table 8c:The effect of education and exercise/physical activity on spinal health (continued)

Study ID	Baseline	1st follow-up	Description	Statistics	Repeated follow-up	Description	Statistics
13	**BP prevalence** Ed/PA = 28%; ED = 31%; CG = 31%	Post – intervention	No change in all groups; no significant difference between groups Age had no effect on results	**BP prevalence** Ed/PA = 27%; Ed = 30%; CG = 34%; p > 0.05 p = 0.86	N/A	N/A	N/A
14	**BP and/or NP prevalence** **Total sample**: NR	Post – intervention		**BP and/or NP prevalence %** Total sample: IG =31, CG = 33	1 year post-intervention	Decrease in both groups compared to post-intervention; no significant difference between groups	**BP and/or NP prevalence %** Total sample: IG = 26, CG = 26; p > 0.05
	With/without teachers' support: NR			**With/without teachers' support %** IG with support = 28 IG without support =30		Decrease in both groups compared to post-intervention; no significant difference between groups Gender had no effect on results	**With/without teachers' support %** IG with support = 22; IG without support = 28 p > 0.05 p > 0.05
15	**BP and/or NP prevalence** NR	Post – intervention		**BP and/or NP prevalence %** IG= 29; CG = 32	2 years post-intervention	Decrease in both groups compared to post-intervention; no significant difference between groups Gender had no effect on results	**BP and/or NP prevalence %** IG= 20; CG = 23; p > 0.05 p > 0.05
17	**BP and/or NP prevalence** **Total group** IG = 31%; CG = 31%	Post – intervention	Decrease in IG, increase in CG; No significant difference between groups	**BP and/or NP prevalence** **Total group (between groups)** IG = 30%; CG = 34%; p >0.05	n/a	n/a	n/a
	BOYS IG = 32%, CG = 22% **GIRLS** IG = 29%, CG = 39%		Decrease in IG and increase in CG; no significant difference between groups for boys; Increase in IG and decrease in CG; no significant difference between groups for girls No significant difference between boys and girls in the IG compared to CG	**BOYS (between groups)** IG = 27%; CG = 34% ; p < 0.09 **GIRLS (between groups)** IG = 33%; CG = 34% ; p >0.05 p < 0.07			
	Pain intensity (no pain, little bit of pain) IG = 53%, CG = 62%		Increase in both groups	**Pain intensity (no pain, little bit of pain)** IG = 75%; CG = 77%			
	Pain frequency (only once or several times) IG = 78%, CG = 89%		Increase in IG and decrease in CG	**Pain frequency (only once or several times)** IG = 80%; CG = 83%			

BP: Back Pain; Ed: Education; PA: Physical Activity; NP: Neck Pain; LBP: Low Back Pain; IG: Intervention group; CG: Control Group; NR: Not Reported; NS: Not significant, NDI: Neck Disability Index; VAS: Visual Analogue Scale; 1 Ruivo et al., 2017; 2 Hill and Keating; 2015; 3 Candy et al., 2012; 4 Fanucchhi et al., 2009; 5 Jones et al., 2007; 6 Rupesh et al., 2016; 7 Ebied, 2015; 8 Syazwan et al., 2011; 9 Dolphens et al.; 2011; 10 Dockrell et al., 2010; 11 Bauer and Freivalds, 2009; 12 Saarni et al., 2009; 13 Cardon et al., 2007; 14 Geldhof et al., 2007a; 15 Geldhof et al., 2007b; 16 Koskelo et al., 2007; 17 Geldhof et al., 2006; 18 Cardon et al., 2004; 19 Candy et al., 2004; 20 Goodgold and Nielsen, 2003; 21 Shelley Goodgold, 2003; 22 Cardon et al., 2002a; 23 Méndez and Gómez-Conesa, 2001; 24 Linton et al., 1994

Table 8c: The effect of education and exercise/physical activity on spinal health (continued)

Study ID	Baseline	1st follow-up	Description	Statistics
23	**LBP prevalence:** No children reported LBP	4 years post intervention	1 IG, 4 placebo and 4 CG participants presented with LBP, no significant difference between groups	**LBP prevalence n (%)** *Control = 8 (12.90); IG = 1 (3.23); X2 = 2.21; P = 0.14
	Well-being (Medical treatment required for LBP) No children in need of medical treatment related to spinal pain		3 placebo and 3 CG participants required medical treatment; no significance between groups	**Well-being (Medical treatment required for LBP) n (%)** *Control = 6 (9.68); IG = 0; p = 0.07
	Scoliosis NR		Scoliosis diagnosed in 1 placebo participant and 2 CG participants; no significance between groups Corsets and insoles prescribed for participants with scoliosis; Insoles also prescribed for 1 CG participant who did not have scoliosis	**Scoliosis**, n (%): *Control = 3 (4.84); IG = 0; p = 0.21 **Corsets for scoliosis** n (%): *Control = 3 (4.84); IG = 0; p = 0.21 **Insoles for scoliosis** n (%): *Control = 4 (6.45); IG = 0; p = 0.15 ***(Control = CG + Placebo)**

BP: Back Pain; Ed: Education; PA: Physical Activity; NP: Neck Pain; LBP: Low Back Pain; IG: Intervention group; CG: Control Group; NR: Not Reported; NS: Not significant, NDI: Neck Disability Index; VAS: Visual Analogue Scale; 1 Ruivo et al., 2017; 2 Hill and Keating; 2015; 3 Candy et al., 2012; 4 Fanucchhi et al., 2009; 5 Jones et al., 2007; 6 Rupesh et al., 2016; 7 Ebied, 2015; 8 Syazwan et al., 2011; 9 Dolphens et al.; 2011; 10 Dockrell et al., 2010; 11 Bauer and Freivalds, 2009; 12 Saarni et al., 2009; 13 Cardon et al., 2007; 14 Geldhof et al., 2007a; 15 Geldhof et al., 2007b; 16 Koskelo et al., 2007; 17 Geldhof et al., 2006; 18 Cardon et al., 2004; 19 Candy et al., 2004; 20 Goodgold and Nielsen, 2003; 21 Shelley Goodgold, 2003; 22 Cardon et al., 2002a; 23 Méndez and Gómez-Conesa, 2001; 24 Linton et al., 1994

Furniture

Table 8d reports on the effectiveness of ergonomically designed furniture and/or adjustment to classroom furniture. NP, UBP, LBP and spinal pain prevalence; NP and spinal pain intensity; BP frequency and BP incidence; as well as spinal well-being were the outcomes of interest. Six studies investigated the short-term effects of the intervention up until 10 weeks post-intervention [74,78,80,84,86,91] and only one study evaluated the effectiveness in the long-term [92].

1) Effect on spinal health

Spinal pain intensity [77,94] and spinal pain prevalence [94] decreased significantly with the introduction of a high-density foam wedge. NP prevalence decreased significantly, but the same intervention had no effect on LBP prevalence [87]. Linton et al. [95] showed that ergonomically designed furniture significantly reduced BP prevalence but had no effect on BP frequency. Cardon et al. [89] and Saarni et al. [80] reported a negative impact of their interventions on spinal pain prevalence and spinal pain intensity respectively.

2) Effect on spinal well-being

The participants in the study by Linton et al. [95] significantly liked their ergonomically designed furniture more than those participants exposed to the traditional furniture. Dockrell et al. [81] found a significant decrease in body discomfort of school children after an ergonomic intervention was implemented. The “moving school” as described by Cardon et al. [89] did not result in changes in the spinal well-being of the children.

Table 8d: The effect of furniture on spinal health

Study ID	Baseline	1st follow-up	Description	Statistics
3	**BP intensity** NR	Post-intervention	Significant decrease in IG; nothing reported for CG	**95% CI** = 0.341 to 1.077, decrease = 0.709 points (58%)
			Significantly more pain in the evening than in the morning in both groups	**Evening:** 95% CI= 0.302 to 0.591, p < 0.001
			Significant reduction per half day in the IG, NR for CG	**Intervention × time:** 95% CI= −0.025 to −0.001, p = 0.036
			Significantly smaller increase in evening back pain in the IG compared to CG	**Intervention × evening:** 95% CI=−0.543 to −0.104, p= 0.004
10	**Pre-intervention:** **BDC/VAS1 (before class) n=21** **Discomfort n(%):** 8 (38); **Area (%):** BP= 14, NP= 5 **Pain intensity:** Mean = 0.9 ± 1.5.	10 weeks post intervention	Reports of discomfort similar at the start of both classes; Fewer reports of BP and more reports of NP at start of follow-up class Pain intensity higher at start of follow-up class; No significant difference between pre-and post-intervention	**BDC/VAS3 (before class) n=22** **Discomfort n(%):** 9 (43); **Area (%):** BP= 9, NP= 9 .**Pain intensity:** Mean = 1.5 ± 2.1; p = 0.49
	BDC/VAS2 (after class) **Discomfort n(%):** 14(67); **Area (%):** BP:19 **Pain intensity:** Mean = 1.8 ± 1.5		Increase in percentage of children experiencing discomfort after both classes Increase in intensity after both classes, however no significant difference between pre-and post-intervention	**BDC/VAS4 (after class)** **Discomfort n(%):** 14(64); **Area (%):** BP: 23, NP: 14 **Pain intensity:** Mean = 2.2 ± 2.2; p = 0.76
	Significant difference between pain intensity before and after class: p = 0.04		No significant difference in pain intensity before and after class The **"net" discomfort** between the pre-intervention class and the post-intervention class was significant	p = 0.21 p = 0.00
16	**NSP prevalence** 23 (76.7%) children of total group (NR per group)	Post intervention	Decrease in both groups; significant difference within groups	**NSP prevalence (within groups)** IG: P = 0.001; CG: P = 0.033
	LBP prevalence: NR		No change in LBP in both groups	**LBP prevalence:** NR
18	**NP/BP prevalence** No data collected prior to study	Post-intervention	No significant difference between groups	**NP/BP prevalence n(%) (between groups)** IG: 9 (40.9%) and CG: 6 (24%); χ2 = 1.54, p = 0.21
	Well-being **Visited the doctor** No data collected prior to study		5 IG participants and 6 CG participants reported ever having visited a doctor for BP or NP; no significant difference between groups	**Well-being** **Visited the doctor** (between groups) IG: 5 (22.7%) and CG: 6 (24%); p = 0.99
	Used medication No data collected prior to study		No IG participants and 3 CG participants reported having used medication for BP or NP; no significant difference between groups	**Used medication** (between groups) IG: 0 and CG: 3 (12%); p = 0.06
19	**BP intensity** (median) - IG: 12.50; CG: 17.00	Post-intervention	Significant decrease in both groups, significant difference between groups	**BP intensity** (median) - IG: 0.36; CG: 2.00; p<0.001 (between groups)
	BP Incidence (median) - IG: 3.00; CG: 5.00		Significant decrease in both groups, significant difference between groups	**BP Incidence (median) -** IG: 0.15; CG: 0.50; p<0.001 (between groups)
24	**BP Prevalence IG** = 50%; CG = 57%	5 months post-intervention	Decrease in IG and increase in CG; significant difference between groups	**BP prevalence (between groups)** IG = 38%; CG = 66%; p < 0.04
	BP Frequency: NR		Decrease in IG and increase in CG; no significant difference between groups	**BP frequency (between groups)** p > 0.05 NS
	NP prevalence: NR		Group differences not significant (nothing reported per group)	**NP prevalence (between groups)** p = 0.07 (NS)
	Sum of assessed symptoms: NR		Decrease in both groups; no significant difference between groups	**Sum of all assessed symptoms (between groups)** p = 0.06 (NS)
	Reports of comfort: NR		Increase in IG and decrease in CG; significant difference between groups	**Reports of comfort (between groups)** p < 0.001 (overall); p < 0.0001 (liking their chair); p < 0.0001 (liking their desk)

NR: Not Reported; IG: Intervention group; CG: Control Group; BM: Body Mass; NS: Not significant; NSP: Neck-Shoulder Pain; LBP: Low Back Pain; NP: Neck Pain; BP: Back Pain
1 Ruivo et al., 2017; 2 Hill and Keating; 2015; 3 Candy et al., 2012; 4 Fanucchhi et al., 2009; 5 Jones et al., 2007; 6 Rupesh et al., 2016; 7 Ebied, 2015; 8 Syazwan et al., 2011; 9 Dolphens et al.; 2011; 10 Dockrell et al., 2010; 11 Bauer and Freivalds, 2009; 12 Saarni et al., 2009; 13 Cardon et al., 2007; 14 Geldhof et al., 2007a; 15 Geldhof et al., 2007b; 16 Koskelo et al., 2007; 17 Geldhof et al., 2006; 18 Cardon et al., 2004; 19 Candy et al., 2004; 20 Goodgold and Nielsen, 2003; 21 Shelley Goodgold, 2003; 22 Cardon et al., 2002a; 23 Méndez and Gómez-Conesa, 2001; 24 Linton et al., 1994

Table 8d: The effect of furniture on spinal health (continued)

Study ID	Baseline	1st follow-up	Description	Statistics	2nd follow-up	Description	Statistics
12	<u>Pain intensity</u> mean (SD) **VAS scores (last 6 months)** **NSP** IG: 44.5 (26.5); CG: 30.2 (27.1) **Upper back** IG: 27.4 (28.6); CG: 22.9 (26.9) **Low back** IG: 32.5 (28.8); CG: 26.1 (29.7)	1st year (14 months) (IG = 42; CG = 46)	Decrease in both groups for all sites	<u>Pain intensity</u> mean (SD) **VAS scores (last 6 months)** **NSP** IG: 33.4 (25.2); CG: 22.3 (20.7) **Upper back** IG: 24.3 (23.0); CG: 16.4 (19.7) **Low back** IG: 26.4 (25.9); CG: 19.7 (22.2)	2nd year (26 months) (younger group only: IG = 22, CG = 19)	Decrease in both groups for NSP compared to total group at baseline Increase in IG and decrease in CG for upper back compared to total group at baseline Increase in IG and decrease in CG for low back compared to total group at baseline	<u>Pain intensity</u> mean (SD) **VAS scores (last 6 months)** **NSP** IG: 42.0 (23.7); CG: 23.1 (27.0) **Upper back** IG: 41.6 (26.8); CG: 13.1 (16.7) **Low back** IG: 38.3 (24.0); CG: 21.7 (24.2)
	Present strain **NSP** NR **Upper back** NR **Lower back** NR **Present pain** **NSP** NR **Upper back** NR **Lower back** NR		No significant change in strain and present pain in IG for all sites; Significant increase in strain and present pain for all sites in CG; No significant change for pain in last 6 months in both groups for all sites	<u>**Within group differences: IG/CG**</u> **NSP** Strain: NS/0.004; Present pain: NS/0.000; Pain last 6 months: NS **Upper back** Strain: NS/0.001; Present pain: NS/0.000; Pain last 6 months: NS **Lower back** Strain: NS/0.000; Present pain: NS/0.000; Pain last 6 months: NS		No significant change in strain, present pain and pain in last 6 months in IG, however significant decrease in all symptoms for CG No significant change in strain and present pain in IG, but significant decrease in CG; Significant decrease in pain in last 6 months in IG; No change in CG No significant change in strain in IG, however significant decrease in CG; Present LBP intensity levels increased significantly in IG and decreased significantly in CG; Significant decrease in pain in last 6 months in IG; No change in CG	<u>**Within group differences: IG/CG**</u> **NSP** Strain: NS/0.003; Present pain: NS/0.000; Pain last 6 months: NS/0.042 **Upper back** Strain: NS/0.001; Present pain: NS/0.000; Pain last 6 months: 0.003/NS **Lower back** Strain: NS/0.000; Present pain: 0.001/0.000; Pain last 6 months: 0.002/NS
			Significant differences in present strain and pain symptoms for all sites, with a decrease in CG and no significant change in IG; No significant difference for pain in past 6 months for all sites in both groups	<u>**Between group differences**</u> **NSP** Strain: p=0.008; Present pain: p=0.004; Pain last 6 months: NS **Upper back** Strain: p=0.010; Present pain: p=0.001; Pain last 6 months: NS **Low back** Strain: p=0.005; Present pain: p<0.0001; Pain last 6 months: NS		Significant differences between groups with symptoms in IG remaining stable and a decrease in CG	<u>**Between group differences**</u> **NSP** Strain: p=0.000; Present pain: p<0.0001; Pain last 6 months: p=0.001 **Upper back** Strain: p = 0.013; Present pain: p<0.0001; Pain last 6 months: p=0.002 **Low back** Strain: p<0.0001; Present pain: p<0.0001; Pain last 6 months: p=0.008

LBP: Low Back Pain; IG: Intervention group; CG: Control Group; NP: Neck Pain; BP: Back Pain; N/A: Not Applicable; VAS: Visual Analogue Scale; NR: Not Reported; NS: Not significant, BM: Body Mass, NSP: Neck-Shoulder Pain; 1 Ruivo et al., 2017; 2 Hill and Keating; 2015; 3 Candy et al., 2012; 4 Fanucchhi et al., 2009; 5 Jones et al., 2007; 6 Rupesh et al., 2016; 7 Ebied, 2015; 8 Syazwan et al., 2011; 9 Dolphens et al.; 2011; 10 Dockrell et al., 2010; 11 Bauer and Freivalds, 2009; 12 Saarni et al., 2009; 13 Cardon et al., 2007; 14 Geldhof et al., 2007a; 15 Geldhof et al., 2007b; 16 Koskelo et al., 2007; 17 Geldhof et al., 2006; 18 Cardon et al., 2004; 19 Candy et al., 2004; 20 Goodgold and Nielsen, 2003; 21 Shelley Goodgold, 2003; 22 Cardon et al., 2002a; 23 Méndez and Gómez-Conesa, 2001; 24 Linton et al., 1994

Short- and long-term effectiveness

The results were grouped according to short- and long-term effectiveness (Tables 9a and 9b). All the interventions, except exercise, investigated the effectiveness in the short- and long-term. Interventions were area-specific, and the effectiveness was better illustrated when isolated to the lower back, neck or the whole spine. Areas of the spine were defined as follows: 1) studies not specifying a specific region of the spine, or that looked at the whole spine, or combined BP and NP were categorised as spinal pain; 2) studies reporting on LBP and/or UBP were categorised as BP; 3) studies evaluating NP and/or neck-shoulder pain, were categorised as NP. Tables 9a and 9b presents the statistical significance and within- or between-group differences of the effectiveness of the interventions on the various outcomes (refer to Table 3 in the Methods section).

Short-term effectiveness

Exercise and education (individually), resulted in significant decrease in BP intensity [74,78], BP prevalence [79] and an increased participation in sport [74]. The combination of exercise and education significantly decreased BP prevalence [76]. NP intensity, prevalence and spinal well-being were significantly improved by the combination of exercise and education, education alone and furniture adjustments respectively [79,87,96]. Spinal pain intensity was significantly impacted by education only [94] and furniture [77,94]; spinal pain prevalence was significantly decreased by education only [80] and adaptations to furniture [94] and spinal discomfort were significantly improved by modifications to furniture [81]. Saarni et al. [83] however, found significant negative differences between groups for UBP, LBP and NP intensity when furniture was adjusted. Spinal well-being was significantly and positively affected by three out of the four interventions i.e. exercise only, exercise and education combined and furniture. Table 9a reports on the short-term effectiveness of the respective intervention types.

Long-term effectiveness

Spinal pain was significantly decreased by education only [80,92] yet when the children were followed up after eight years, the education intervention resulted in a significant negative effect [80]. Modifications to furniture significantly decreased BP prevalence and resulted in a significant improvement in the comfort the children experienced when the new ergonomically designed furniture was introduced [95]. Table 9b reports on the long-term effectiveness of the respective intervention types.

Table 9a: Short-term effectiveness of interventions (The number indicates the ID of the study involved)

Spinal health outcomes	Exercise only (3 studies)			Education only (7 studies)				Exercise and Education (7 studies)			Furniture (7 studies)					
BP Intensity	++ 5 (LBP) ++ 4 (LBP) (past month)	*4 (LBP) (current)													-12 past 6 months (UBP) -12 past 6 months (LBP)	--12 (current) UBP --12 (current) LBP
NP Intensity								+6							-12 past 6 months	--12 (current)
Spinal pain (BP and NP) Intensity				++ 7					*17		++19	+3				
BP Prevalence					+ 8 (UBP)		°8 (LBP)	+2 (LBP)	*2 (LBP); *13					°16 (LBP)		
NP prevalence		* 1			+ 8							+16				
Spinal pain (BP and NP) prevalence				++ 9		*22	°21		* 17		++19			-18		
BP frequency		*5 (LBP)														
Spinal pain (BP and NP) Frequency									*17							
BP duration										-2 (LBP)						
Well – being		*4				*20, 21		+6								
Well-being: visit to HCP/ used medication										°2			*18			
Well -being: feeling about school/ life			°4													
Absence from/ participation in sport/ PA	++5									°2						
Absence from school/ school attendance			°5							°2						
Comfort/ exertion							-11					+ 10				

BP: Back Pain; NP: Neck Pain; LBP: Low Back Pain; UBP: Upper Back Pain; 1 Ruivo et al., 2017; 2 Hill and Keating; 2015; 3 Candy et al., 2012; 4 Fanucchhi et al., 2009; 5 Jones et al., 2007; 6 Rupesh et al., 2016; 7 Ebied, 2015; 8 Syazwan et al., 2011; 9 Dolphens et al.; 2011; 10 Dockrell et al., 2010; 11 Bauer and Freivalds, 2009; 12 Saarni et al., 2009; 13 Cardon et al., 2007; 14 Geldhof et al., 2007a; 15 Geldhof et al., 2007b; 16 Koskelo et al., 2007; 17 Geldhof et al., 2006; 18 Cardon et al., 2004; 19 Candy et al., 2004; 20 Goodgold and Nielsen, 2003; 21 Shelley Goodgold, 2003; 22 Cardon et al., 2002a; 23 Méndez and Gómez-Conesa, 2001; 24 Linton et al., 1994

++	(Positive) significant difference between groups
+	Significant difference within IG
*	Improvement in IG, but no significance
°	No change in IG
-	Negative effect in IG
--	(Negative) significant difference between groups

Table 9b: Long-term effectiveness of interventions (The number indicates the ID of the study involved)

Spinal health outcomes	Education only (7 studies)		Exercise and Education (7 studies)	Furniture (7 studies)		
BP Prevalence			*(LBP)23	++24		
NP prevalence					°24	
Spinal pain prevalence	++(1yr)9; ++ (1yr)22	--(8yr)9	*14, *15			
BP frequency					*24	
Well-being: visit to HCP/ used medication			*23			
Comfort/ exertion				++24		

BP: Back Pain; NP: Neck Pain; LBP: Low Back Pain; UBP: Upper Back Pain; 1 Ruivo et al., 2017; 2 Hill and Keating; 2015; 3 Candy et al., 2012; 4 Fanucchhi et al., 2009; 5 Jones et al., 2007; 6 Rupesh et al., 2016; 7 Ebied, 2015; 8 Syazwan et al., 2011; 9 Dolphens et al.; 2011; 10 Dockrell et al., 2010; 11 Bauer and Freivalds, 2009; 12 Saarni et al., 2009; 13 Cardon et al., 2007; 14 Geldhof et al., 2007a; 15 Geldhof et al., 2007b; 16 Koskelo et al., 2007; 17 Geldhof et al., 2006; 18 Cardon et al., 2004; 19 Candy et al., 2004; 20 Goodgold and Nielsen, 2003; 21 Shelley Goodgold, 2003; 22 Cardon et al., 2002a; 23 Méndez and Gómez-Conesa, 2001; 24 Linton et al., 1994

++	(Positive) significant difference between groups
+	Significant difference within IG
*	Improvement in IG, but no significance
°	No change in IG
-	Negative effect in IG
--	(Negative) significant difference between groups

Phase one – Systematic Review: Search strategy B

A comprehensive search, using twelve Guideline Clearinghouses and databases, was conducted since inception of the databases up to July 2017. A total number of 3450 hits were produced. One reviewer screened the titles and abstracts of all the hits for eligibility and inclusion in this review. A total of 3443 hits were discarded as it did not meet the inclusion criteria based on the title and/or abstract. Seven full text documents were screened for eligibility and, only six met the inclusion criteria and were included in this review.

Description of the grey literature

The characteristics of the included grey literature are described in Table 10. The six documents consisted of two guideline documents [57,107] of which one was also presented in a newsletter [107]. The other four documents included a school policy document designed by a physiotherapist [108], a fact sheet (educational pamphlet) developed by the Healthy Schools Network Incorporated, a document detailing initiatives about the correct usage of schoolbags in two countries [109] and a document describing an Ergonomics, Movement, Posture (EMP) program designed for Physical Education (PE) teachers to implement at schools as part of their practical training. Three of these documents are based in Europe [57,107,108]. Two initiatives are based in the USA [109,110] and in Sri-Lanka [109]. The EMP program is based in Israel [110].

Table 10: Characteristics of the grey literature

No.	Title	Author and year (date)	Country	Type of document
1	Guidelines on schoolbag use: Messaging to inform the stakeholders	Dockrell et al., 2016	Ireland	Guideline document
2	Global healthy backpack initiatives	Jayaratne et al., 2012	Sri-Lanka and USA	Report paper
3	School Back Care Policy (Primary) – Ensuring Good Back Health for Pupils and Staff	Lorna Taylor (February 2010)	UK	School policy document
4	Chapter 2: European guidelines for prevention in low back pain THE BACK LETTER	Burton et al., 2006 Lippincott Williams & Wilkins (March 2005)	Europe	Guideline document Newsletter
5	Learning Without Pain: ERGONOMICS PREVENTS INJURIES	Healthy Schools Network Inc	USA (NY)	Fact sheet
6	Ergonomics for children: An educational program for elementary school	Heyman and Dekel 2009	Israel	Report paper

1 Dockrell et al., 2016; 2 Jayaratne et al., 2012; 3 Taylor 2010; 4 Burton et al., 2006; 5 Healthy Schools Network Inc; 6 Heyman and Dekel, 2009

Content of the grey literature

Table 11 describes the content of the respective grey literature documents. Education was the main theme of intervention and included information such as risk factors for spinal pain; proper schoolbag use; ergonomics and posture; and exercise and diet. The proper use of schoolbags was highlighted in all six documents. Three of the studies incorporated experts and government or educational authorities in the creation of the guideline document, fact sheet and report paper [107,109,110]. Two of the six documents are based on observational or cross-sectional studies [109,110], however the other four documents have no reported evidence base of support.

Table 11: Description of grey literature content

No.	Type of intervention	Content	Implementation or tested	Development of policy/guidelines	Supporting scientific evidence base
1	Education - schoolbags	**Guidelines for schoolbag use:** Adjustable padded shoulder straps to fit child's back, padded back and hip strap, packing bag with heaviest closest to the back, bag worn on back over both shoulders, carry only what is needed and when necessary, proper donning and doffing, involve school in terms of time tabling to minimise need for all books to be brought to school; Addressed to stakeholders: users (children), providers (parents, retailers) manufacturers of schoolbags, and other stakeholders such as teacher organisations, health care professionals, and policy makers	NR	The authors	NR
2	Education on backpack use	National Healthy Schoolbag Campaign of Sri Lanka: Sri Lanka standards on schoolbags formulated	YES: Text books were split into several volumes; Only page-80 exercise books were recommended; healthy schoolbag with ergonomic features was modelled based on Sri Lankan contexts; Bag manufacturers were registered and educated on design of model healthy bag; children, parents and teachers were educated through mass media, leaflets and at exhibitions.	Working committee consisted of Paediatricians, Public Health Specialists, Education administrators, Standard Engineers, Ergonomists, Textile Engineers and Bag manufacturers	Based on descriptive cross-sectional analysis on carriage of schoolbag and negative health outcomes
		"Pack it Light, Wear it Right" public health backpack initiative in the United States: how to select the right backpack, how to pack it right and how to wear it correctly	YES: For more than 10 years - Backpack Awareness events (in schools, community centres, and retail facilities), TV and newspaper coverage (www.aota.org)	American Occupational Therapy Association (AOTA) initiative	N/R
3	Education	• Background/stats • Risk factors • Recommendations: 1) Proper schoolbag use; 2) Sitting: frequent postural changes, correct height of furniture; 3) Lifting and carrying for pupils and staff - back care principles and training; 4) Exercise – core incorporated in PE classes; 5) Diet; 6) Psychological issues; 7) Growth spurts • Management	NR	The author in conjunction with "the voice- union for educational professionals"	NR
4	Education	• School-based interventions; • Life style factors: obesity, smoking, eating habits, alcohol intake, sports/physical activity, sedentary activities, work; Physical factors: mobility/flexibility, fitness, muscle strength; • School-related factors: school bags, furniture; • Psychosocial factors	NR	European Commission, Research Directorate-General, department of Policy, Co-ordination and Strategy in conjunction with the Working Group (WG) who consisted of experts in the field of low back pain research	NR
5	Education - schoolbags and computer use	Basic information to parents and school staff on using ergonomic practices to prevent computer and backpack-related stresses: ergonomically correct workstations and computer use; correct schoolbag use	NR	The Healthy Schools Network in conjunction with the Beldon Fund and the Educational Foundation of America	Based on experimental/ observational study by Guyer, 2001
6	Education and physical activity	The human body: structure and function Movement, balanced posture and body awareness Sitting Lifting, pushing and carrying (schoolbags) Special education	YES: The program has been taught in elementary schools by Physical Education students in Israel, however not part of the curriculum	Department of Physical Education and Movement at the Kibbutzim College of Education in Israel	NR

NR: Not reported; 1 Dockrell et al., 2016; 2 Jayaratne et al., 2012; 3 Taylor 2010; 4 Burton et al., 2006; 5 Healthy Schools Network Inc; 6 Heyman and Dekel, 2009

Phase two: Development of the schematic presentation of current best evidence (framework)

Developing the schematic presentation (framework) required intensive scrutiny of the results. The framework being referred to in this study forms the basic structure of the synthesised evidence collected from the systematic review. It will be contextualised to fit into the South African environment when other facets of the bigger project are incorporated into this framework. From Tables 9a and 9b, the positive significant between- and within-group results were identified, and only those results were used to create the framework. Two pictures of a school building depicted the effectiveness of the interventions in the short- and long-term (Figures 3 and 4 respectively). The effectiveness of the interventions was grouped according to the spinal health outcomes related to the area of the spine i.e. BP, NP and spinal pain. The spinal well-being outcomes were included with the spinal area which they relate to. From Table 9a, it is clear that exercise and education, individually as well as combined were effective in improving different aspects of BP. The combination of exercise and education, education alone and furniture were the type of interventions that befitted NP, whereas spinal pain was improved with adaptations to furniture and with an educational program. These interventions were all successful in the short-term. In the long-term, as deduced from Table 9b, BP was positively affected by adaptations to furniture and spinal pain by education. None of the studies reported on the long-term effectiveness of improving NP in children and adolescents.

The content of two of the grey literature documents [109,110] was incorporated in the schematic presentation of the current best evidence for school-based interventions aimed at improving spinal health in children and adolescents. These two documents have a scientific evidence base of support and the content of the education programmes are presented in the steps of the schoolhouse building in both the short- and long-term time periods of the effectiveness of the interventions.

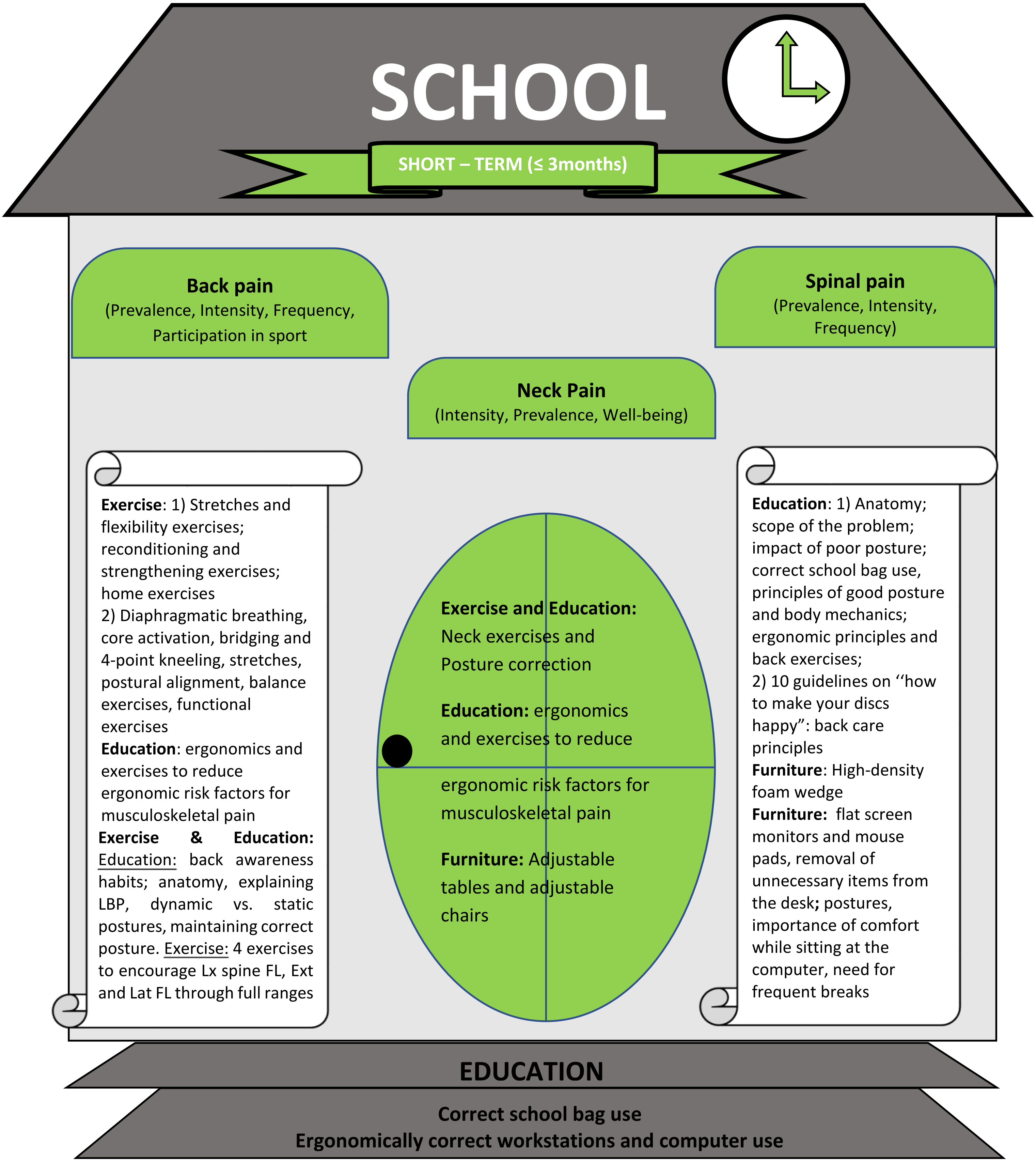

Figure 3: School framework of short-term effectiveness

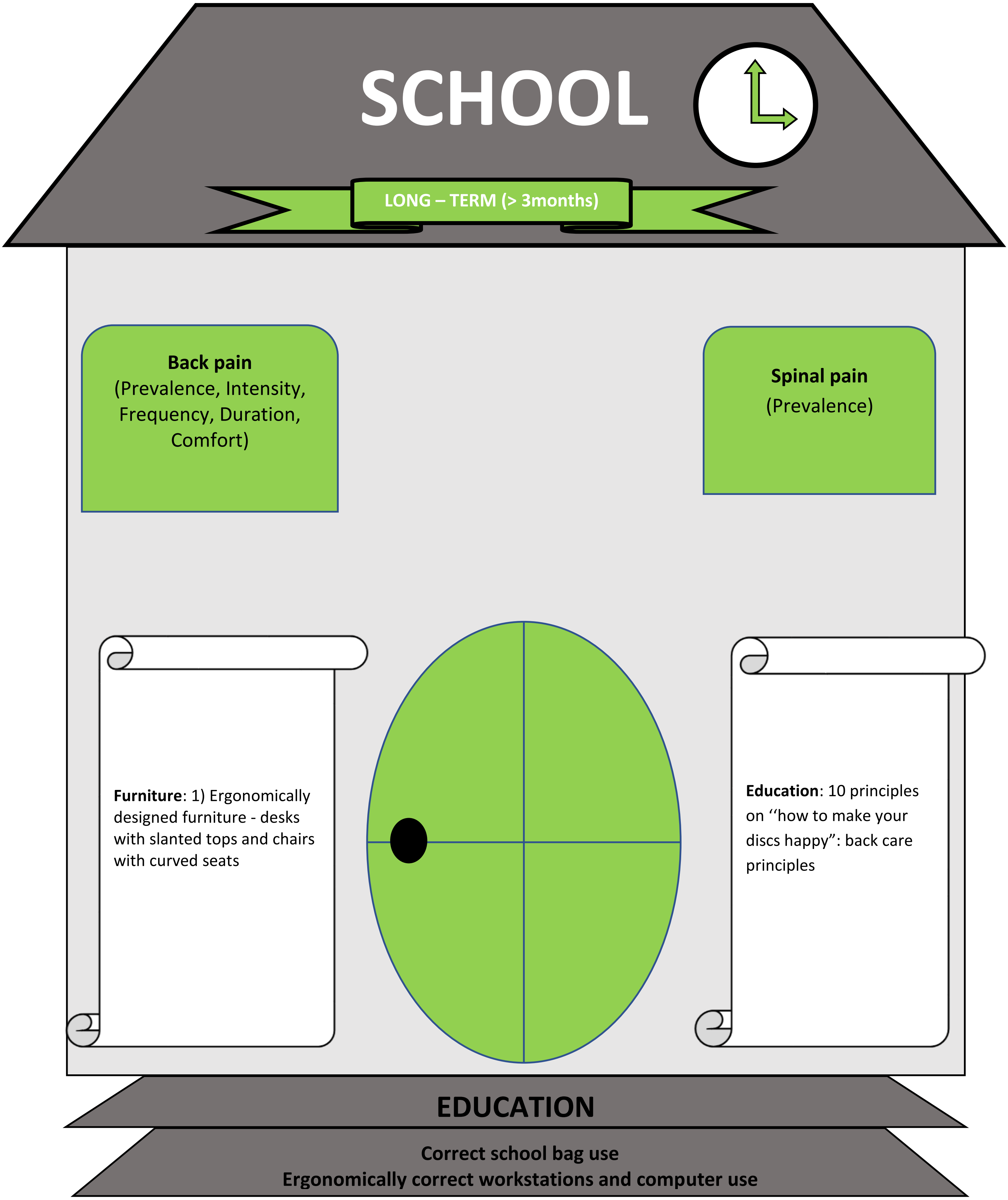

Figure 4: School framework of long-term effectiveness

DISCUSSION

The aim of this review was to determine the effectiveness of school-based interventions in promoting spinal health in children and adolescents as well as to create a schematic presentation of the current best evidence as a framework in the form of two pictures of a school building. This data will contribute towards a bigger project of formulating guidelines to promote spinal health in children and adolescents for South African schools specifically Four main themes of intervention i.e. exercise, education, exercise and education and furniture, were identified. The outcome spinal health was defined as either a measure of pain or discomfort in the spine or a measure of wellbeing which was directly related to the presence of spinal pain (all areas of the spine) or discomfort. The findings of this review indicate that each of the four themes of intervention had a statistical significant effect on one or more aspects of spinal health in children and adolescents.

Spinal health (short-term effectiveness)

Regardless of the length of the intervention, most studies only report on the short-term effect of the intervention [74-84,87-91,94,96,97]. Education on its own and furniture adjustments yielded the most significant positive effects on spinal health in children and adolescents when the spinal health outcomes (pain and well-being) of the whole spine was considered. All four types of intervention were effective when the spinal health outcomes (pain and well-being) were more area specific i.e. NP versus BP (UBP and LBP).

Furniture

Modifications to furniture were investigated in studies with either a short duration (up to 10 weeks) or longer duration (from six to 26 months) of intervention implementation. The studies with a shorter duration of furniture adjustment resulted in more significant positive results on spinal pain [77,81,94] whereas modified school furniture implemented for longer periods (up to 26 months) resulted in negative outcomes for NP and BP [83] or no significant difference in the results for spinal pain [86] except for Koskelo et al. [87] and Linton et al. [95]. In both the studies by Koskelo et al. [89] and Linton et al. [95], significant improvement of NP and BP respectively, were found. The furniture interventions of shorter duration were relatively simple i.e. the foam wedge that was used in Candy et al. [77,94] and the simple changes to computer workstations demonstrated in Dockrell et al. [81], and the simplicity of the intervention combined with the shorter duration of implementation might be the reason why significant improvement in spinal pain was found. Koskelo et al. [89] reported that all the participants complied with the intervention all the time which potentially could have led to the significant positive change in NP, whereas the intervention in Saarni et al. [83] had various factors that could have influenced the results negatively such as: only the younger group in the study completed the intervention; the conventional furniture seemed to have been similar to the intervention furniture; and the anticipated school hours which the children were going to use the furniture were reduced since the participants moved between classes and used different furniture during the course of the day instead of only the intervention furniture. Using different furniture during the intervention period, could have led to participants' exposure to different spinal postures resulting in no consistency in the assumed posture of the participants [83] as was the case with Candy et al. [77,94] where the participants used the foam wedge constantly and with Koskelo et al. [87] where the furniture had wheels to accommodate for when the participants had to move between classes. Linton et al. [95] reported on a significant improvement in comfort which could also be a reason for the significant improvement in BP in the participants or vice versa could be true i.e. because they had less pain, the participants reported an increased experience of comfort. It appears that even with a longer intervention duration (two years versus four weeks), the impact becomes resolute if the spinal posture, which is created by the furniture adjustment, is not maintained throughout the school day. It is evident that furniture adjustments were more effective in addressing the experience of pain in the whole spine, rather than impacting isolated areas of the spine i.e. neck, upper back and lower back. This could potentially be attributed to the fact that furniture adjustments generally include various components, such as elbow height and arm dimensions; knee and popliteal height; seat height, slope and depth; table height and desk slope, in order to achieve optimal seating which in turn may result in good postural habits and the least amount of discomfort [40]. Lazary et al. [8] also explains the importance of spinal balance or spino-pelvic alignment to minimize complaints of spinal pain or discomfort by limiting energy expenditure. Cardon et al. [89] implemented the "moving school" which incorporated various furniture adjustments and more participants exposed to these adjustments complained of LBP compared to the control group [89]. The participants of the "moving school" were also only eight years old at the time of the study. The authors argued that perhaps a better comparison could be made once the children reached a growth spurt [89]. It has been reported that age influences spinal health and that spinal pain particularly increases after the age of 12 years old [25] which supports the authors' conclusion about the age of the participants potentially being too young.

Education

Educational programs impacted spinal pain [80,97] as well as NP significantly [79]. The content of the educational programs in Ebied [97] and Dolphens et al. [80] were very similar and were implemented in a similar fashion i.e. one session per week over a period of four weeks [97] and six weeks [80]. Syazwan et al. [79] only conducted two sessions (classes), which although was similar to Ebied [97] and Dolphens et al. [80], included other components such as an electronic copy, flyers and posters. All three studies reported that the spinal care knowledge of the participants improved significantly which could explain the decrease in pain, however the spinal behaviour of the participants did not change. [80,79,97]. Similarly, Linton et al. [95], reported that although the participants felt that their sitting behaviour improved, the actual RULA scores, contradicted this. Furthermore Foltran et al. [113] found that although participants' knowledge improved after the implementation of an educational program, the intervention did not necessarily lead to postural behavioural changes. This highlights the importance of the subjective interpretation of pain and discomfort. It is clear from these studies that by improving knowledge about spinal health only, their perception of pain was affected, but not necessarily their behaviour.

Exercise

The effect of exercise alone was only investigated in three studies [74,75,78] of which two studies reported on a significant reduction in LBP [74,78]. The interventions were similar in terms of the duration of the intervention [74,78]. The type of exercises described in these studies by Fanuchhi et al. [75] and Jones et al. [74] concur with Moreira et al. [114] and Allen et al. [115] who argued that improved flexibility and trunk and core muscle endurance, could assist in decreasing the incidence of LBP respectively. Jones et al. [74] illustrated that children participated more in sport or physical activity after being exposed to the intervention to reduce LBP, but school attendance was not affected. This could be due to already low baseline measurements in terms of absenteeism from school compared to higher measurements for weekly participation in and/or absence from sport: i.e. very few children did not attend school due to LBP. The fact that the children were part of an exercise intervention could also have encouraged them to participate more in their sport due to being physically involved whilst they suffer from LBP, but at a lower intensity.

Education and Exercise combined

The implementation of a combination of education and exercise significantly improved NP in terms of intensity and well-being [96]. In this study, teachers were involved in the intervention by supervising the exercises and ensuring that it was done correctly, thus emphasising the important role of the teacher in promoting spinal health in children and adolescents. Simple range of motion exercises were conducted during class time with minimal repetition but resulted in a significant decrease in pain intensity scores and a subsequent significant improvement in Neck Disability Index (NDI) scores. The significant impact of the combination of exercise and education is illustrated in the study by Hill and Keating [73] where the intervention significantly improved LBP prevalence. This was also the only study that found a reduction in the risk of lifetime first episode of LBP, which is an important aspect in the promotion of spinal health, as prevention is better than cure. Once again, the exercises in this intervention were simple range of motion exercises i.e. lumbar spine flexion, extension and lateral flexion through full ranges. These studies demonstrate that with simple exercises and clear educational instructions, spinal health in children can be significantly affected in a positive way.

Spinal health (long-term effectiveness)

Fewer studies reported on the long-term effects of the interventions [80,85,86,92,93,95], of which no studies investigated the effectiveness of exercise on spinal health. Education on its own yielded the most significant positive effects on spinal health outcomes (pain and well-being) of the whole spine. Furniture adjustments were the most effective interventions when the spinal health outcomes (pain and well-being) pertained to BP (UBP and LBP) only.

Education

Education resulted in a significant decrease in spinal pain up to a year post intervention [80,92], but Dolphens et al. [80] reported a significant worsening of the spinal pain after eight years follow-up [80]. This study had a large drop-out rate (46.6%) which affected the generalisability of the results [80] and although the intervention group showed significantly higher pain prevalence rates at all test moments compared to the control group, the overall increase from pre-test to 8-year follow-up was higher in the control group compared to the intervention group. Thus, the prevalence of spinal pain increased in both groups. A possible suggestion to maintain the positive effect that was obtained up until one-year post intervention could be reinforcement of the program by involving the teachers more often. Cardon et al. [116] highlighted the important role of the teacher in achieving optimal outcomes when implementing a back-education program in the elementary school environment. Children may respond better to education to improve current discomfort, than they would to prevent spinal pain sometime in the future [95].

Furniture

Linton et al. [95] reported on a significant improvement in BP as well as improvement in the comfort the participants experienced when using the newly designed ergonomic furniture which was implemented for six months. This study also reported that although the participants reported less BP, and believed that their sitting posture improved, the actual observed postural behaviour did not change [95]. This ties in with the debate about whether or not poor posture is related to spinal pain such as described in Lazary et al. [8]. This review presented multiple sentiments from different studies for and against the relationship between posture and spinal pain [8].

Outcome measures and measurement tools

Pain prevalence was most often measured and the review reports on high pain prevalence rates for various parts of the spine such as NP (including neck-shoulder pain), BP, LBP, UBP and spinal pain. This is in accordance with previous literature reporting LBP prevalence ranging from 33% to as high as 48% [4-7, 16, 18] and NP and UBP lifetime prevalence ranging from 3% - 8% and 9% - 72% respectively [9]. Kjaer et al. [16] tracked spinal pain from childhood to adolescence and found that children as young as nine years of age already reported spinal pain with prevalence rates ranging from 4% – 36%, 20% - 35% and 10% to 15% for LBP, UBP and NP respectively [16,17]. The prevalence rates illustrated in this review were generally slightly higher than what was found in previous studies [16,17].

Pain prevalence was mostly measured using self-reported questionnaires. Most of the European studies [80,84,85,88,89] used the same or similar questionnaire which was based on the work by Cardon et al. [92,103] and reported to have good test-retest reliability. Ruivo et al. [75] had one yes/no question related to NP, which the authors later described as a limitation to their study and proposed a more detailed questionnaire to be used in future studies. Although the one question about NP was sufficient to capture the 1-month prevalence of NP, it did not give any detail about the intensity, the frequency or the reason for the pain i.e. whether it was due to injury or other factors. These details could provide a more holistic picture of the experience of the child, and could provide a broader scope when determining the effectiveness of the intervention with more aspects to evaluate more accurately. Hill and Keating [76] also questioned their self-designed questionnaire, but argued that the questionnaire was sensitive enough to detect between-group differences.

Self-reported pain intensity measuring tools, in terms of feasibility, interpretability, validity and reliability have been investigated extensively in the literature [117,118]. Some of the pain intensity measuring tools used in this review include the VAS, NRS and the Wong-Baker face pain rating scale. The VAS has been shown to be well-established with good validity and reliability of the scale [117,118]. The Wong-Baker face pain rating scale is classified as approaching well-established, which means that there is sufficient detail available to evaluate the measure, but the psychometric values are vague or moderate [117,118]. It is argued that the faces are more appropriate for children to describe their pain instead of puzzling words or numbers [118]. The NRS is most often used in adults to rate their pain intensity, but the standardisation of this measurement tool for children/adolescents is questioned as the verbal instruction varies (e.g. worst imaginable pain vs worst pain ever) and depending on the age and experience of the child, may influence their perceptions and answers [117]. Only two studies made use of the NRS, but the age group of these children were 14 – 16 years old [77] and 16 – 18 years old [94] and the children may have been able to better understand and interpret the NRS.

Hierarchy of evidence

Twenty-four studies were included in this review, of which only five of the studies were RCT's. RCT's are considered to be the "gold standard" in determining the effectiveness of therapeutic interventions [119], however more recent literature have provided more insight into the limitations of RCT's such as 1) the ethical component of not providing treatment to the control groups, 2) high costs of conducting the studies, 3) the credibility of intention-to-treat-analysis in cases of high drop-out rates, 4) the small sample sizes and 5) the difficulty in controlling for potential confounding factors within groups which results in incomparable groups at baseline [120,121]. It is argued that although RCT's have resulted in great advancements in medical research, other methods of research should not be disregarded or seen as inferior [120,121].

Methodological quality appraisal

Generally, the studies scored high on the respective appraisal tools. The low score by Candy et al. [77] on the PEDro scale was mainly due to non-blinding of the participants and the researchers, which increased the measurement bias in the study. However, the authors argued that the participants commented negatively on the practicality of the wedge and could equally have reported on experiencing worse BP. The lowest score on the JBI checklist was 4/9, for Goodgold and Nielsen [90] and Goodgold [91].

The low score was as a result of the following: it was unclear whether the participants were similar at baseline; receiving other treatment similar to the intervention was not applicable; and the studies did not have multiple measurements before and after the intervention [90,91]. The follow-up was not adequately reported in Goodgold and Nielsen [90] and the appropriateness of the statistical analysis used in Goodgold [91] was unclear. However, the purpose of including a methodological appraisal of the eligible studies was not to exclude those receiving poor score but for the reviewer to be able to better interpret the findings of the studies.

It is of interest to note that most of the studies hail from Europe and only two in Africa of which one was done in South Africa [78], the other in Egypt [97]. This demonstrates that child and adolescent spinal health is reported on more in Europe than anywhere else in the world. However, it would be incorrect to assume that spinal health in children and adolescents is not receiving the same amount of attention elsewhere in the world, purely based on the lack of published literature.

Grey literature

A review by Cardon and Balague [21] in collaboration with the European Commission Research Directorate General investigated the prevention of LBP in schoolchildren. The results were used to formulate the European guidelines for prevention of LBP in different population groups (general population, the workforce and schoolchildren) [107]. Unfortunately, there was insufficient evidence for or against the current interventions to prevent LBP in children, and guidelines for this population could not be formulated. A physiotherapist from the UK, Lorna Taylor, formulated a policy document which provides information to pupils and staff about good back health [108].

The information in the policy document encompasses various aspects of good spinal habits (as described in Table 11), however upon request, no details of the development of the policy document could be obtained from the author to verify the scientific credibility of the document. Another author, who has written various articles on adolescent spinal health and particularly focusing on schoolbags, created a guideline for schoolbag use, which was addressed to stakeholders such as parents, primary and post-primary school children, teachers, health professionals, manufacturers and retailers [57]. Again, no details on the development of the schoolbag guideline could be obtained from the author. Thus, whether these policy and guideline documents are evidence-based, remains unsure.

There are some similarities between the information found in the grey literature and the findings obtained from search strategy A which included the primary research. The focus on schoolbags is evident from the grey literature as this topic is highlighted in all six documents [57,108-111]. This is supported by the studies by Goodgold and Nielsen [90] and Goodgold [91] where proper schoolbag use improved the children's sense of well-being in terms of identifying the dangers or risk factors of improper schoolbag use and acknowledging the importance of the intervention program.

Schematic presentation of the framework

The aim of the framework was to visually present the current best evidence to promote spinal health in children and adolescents by using the synthesised results from this review. All the interventions had some significant effect on one or more aspects of spinal health. The positive results were evidently more than the negative results as depicted in Tables 9a and 9b. The results also span over more than two decades from

1994 [95] up until 2017 [75] and shows how far research has come but also that this field is still being investigated. The framework illustrates that different types of interventions and combinations thereof promote spinal health in the school environment. For example, BP in children and adolescents was significantly improved by means of education, exercise and the combination of exercise and education. This is true for interventions in the short- and long-term. Although the long-term effects are limited, it is mainly due to a lack of long-term follow-ups. Many of the studies recommended that the interventions be incorporated into the school curriculum to promote spinal health in children [85,90,89,91,93,97]. Hence the development of this framework to assist with the development of guideline formulation and implementation of spinal health promotion programs in schools. Current grey literature has failed to report on the scientific backing for their programs, but with the results of this review, an evidence-based framework can be proposed to assist in the development of guidelines to promote spinal health in schools.

LIMITATIONS AND RECOMMENDATIONS

Only studies published in English were included which potentially limits the inclusion of studies published in other languages. Very few RCT's have been and a meta-analysis was not possible. Other factors that could influence spinal health such as spinal care knowledge and behaviour were excluded and could add valuable information to the overall picture of spinal health promotion in children and adolescents.

If more RCT's are conducted using the same criteria, it will allow for a meta-analysis to be performed which will better summarize the effectiveness of the interventions. Other languages should also be considered as this may allow for more countries to be included and give a better global picture on the spinal health in children and adolescents.

CONCLUSION

The multifactorial problem of spinal pain in school children and adolescents is certainly receiving increasing attention in terms of identifying risk factors and addressing the risk factors by conducting intervention studies. The significant positive effect of the various interventions has been highlighted and although it is difficult if not impossible to determine which intervention is superior to the other, due to various factors, such as age, setting, type of intervention or the combination of interventions, it is still of value to note that each intervention could be beneficial in the promotion of spinal health in children and adolescents. The results of this review can conclude that conflicting evidence is minimal, and the greater part of the review findings support the positive impact of all four interventions on spinal health, in school children and adolescents i.e. exercise was most effective to address LBP; exercise and education influenced neck and LBP the most; education only was most effective to address spinal pain and furniture adjustments impacted mostly neck and spinal pain. The grey literature lacked the scientific evidence base of support and the content of only two documents containing education on schoolbag weight and carriage could be incorporated in the schematic presentation of the evidence-based framework. These results can be used towards formulating recommendations for guidelines to be implemented in South African schools.

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Chapter 3

3.1 LIMITATIONS

One of the limitations of this study is the fact that only English studies were included for review, which could potentially have resulted in the exclusion of good quality studies. Due to the difference in reporting of results in terms of type of intervention, spinal area reported on, outcome measures and sample population, a meta-analysis could not be performed, and results had to be presented descriptively. Many of the authors did not respond or could not be reached in the case where certain details or results were missing, which affects the interpretation of the results and overall conclusion of the review. Only spinal pain and well-being were investigated in this study, whilst other factors that could influence spinal health such as spinal care knowledge and behaviour were excluded and could add valuable information to the overall picture of spinal health promotion in children and adolescents.

3.2 RECOMMENDATIONS AND FUTURE RESEARCH

Future review studies should incorporate the broader aspects of spinal health (posture, spinal care knowledge and behaviour) into their research. This will provide a more holistic view on the public health issue of spinal pain in children and adolescents and possibly provide more solutions to the problem. Other languages should also be considered, to include as many studies as possible. More studies in the South African context will be of value to the current project as different countries have different challenges. This will also assist in applying the correct strategies in the correct environment. When conducting primary research, researchers should implement longer follow-up periods, to evaluate long-term effectiveness and sustainability of interventions. This study is part of a bigger project to formulate spinal health guidelines with the aim to promote spinal health in school-going children in South Africa. The next phase of the project will be to present the evidence to various experts in the field to validate the information. Once the information has been validated, the preliminary guideline will be contextualized to the South African population by incorporating information obtained from another M-research project. The final guideline document will be presented to various stakeholders (i.e. The Department of Education and The Department of Health in South Africa), with the aim to implement it in South African schools.

3.3 CONCLUSION

The relatively large number of included studies (n=24), which have been conducted over 23 years (1994 – 2017) highlights the continued importance of school-based spinal health in children as it is a regularly pursued and investigated field of research. Unfortunately, the results are often conflicting which is partly why no guidelines have been formulated for the promotion of spinal health in children and adolescents. An interesting observation is surrounding the of evidence on the impact of schoolbags on children and adolescents. Although this area of spinal health in children and adolescents is widely researched, it’s impact as well as strategies to promote spinal health in terms of schoolbags, could not be distinctly established in this review. Even in parts of the world where extensive research is being done in this field of child and adolescent spinal health, no school-based guidelines could be established due to insufficient evidence. Considering the impact of spinal pain on the overall community, it is concerning that no specific guidelines could be found that specifically aimed at spinal health promotion in children and adolescents. In view of the results of this study, simple strategies can be implemented with the cooperation of various stakeholders such as parents, teachers, pupils, manufacturers of furniture and schoolbags, that could promote spinal health in children and adolescents. All four interventions are appropriate and useful in the promotion of spinal health in children and adolescents. The review findings support the positive impact of all four interventions on spinal health in school children and adolescents i.e. exercise was most effective to address LBP; exercise and education combined influenced neck and LBP the most; education only was most effective to address spinal pain and furniture adjustments impacted mostly neck and spinal pain. Yet, there is still a void when it comes to spinal health promotion in children and adolescents at school level. It is especially important to consider developing countries who struggle with already limited resources, when creating guidelines and deciding on the implementation thereof. The importance of prevention being far superior to cure should be emphasised so that all parties can come on board to promote spinal health in children and adolescents. There is a need for spinal health guidelines to promote good spinal habits in children and adolescents. There is also a need to do more research on spinal health in children and adolescents in South Africa as only one study out of twenty-four was conducted in South Africa.

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APPENDIX A: Database Search Strategies

PEDRO

1 back pain children
2 back pain children exercise
3 back pain children education
4 back pain children posture
5 back pain children treatment
6 back pain children ergonomics school-based
7 back pain adolescents
8 back pain adolescents school-based
9 back pain adolescents treatment
10 back pain adolescents posture
11 back pain adolescents education
12 neck pain children
13 neck pain adolescents
14 back pain schoolbag back pack
15 neck pain schoolbag back pack
16 neck pain posture
17 guidelines spine children
18 guidelines spine adolescents
19 guidelines spine pain
20 guidelines spine pain children

BIOMED CENTRAL

1 guidelines AND spine AND pain AND (school children)
2 (School children) AND adolescent AND (back pain) AND physiotherapy
3 spine AND pain AND (school children) AND school-based
4 (back pain) OR (neck pain) AND (school children) AND (school-based intervention)
5 (back pain) OR (neck pain) AND (school children) AND posture AND treatment
6 (back pain) OR (neck pain) AND children OR adolescents AND ergonomics
7 (back pain) OR (neck pain) AND (School children) AND (back pack) OR schoolbag
8 (spinal health) AND (School children) AND (back pack) OR schoolbag
9 (spinal health) AND (School children) AND (school-based)
10 (spinal health) AND (School children) AND (educational program) (spinal health) AND (School children) AND exercise

GOOGLE SCHOLAR

1 guidelines spine pain (school children)
2 spine pain (school children) education
3 spine pain (school children) physiotherapy
4 back pain neck pain children adolescent (school-based)
5 spine pain school children ergonomics

6 spine pain school children backpack school bag

COCHRANE LIBRARY
1 children AND adolescent AND (back pain) AND exercise
2 children AND adolescent AND (back pain) OR (neck pain) AND ergonomics
3 children AND adolescent AND (back pain) OR (neck pain) AND (sitting duration)
4 children AND adolescent AND (back pain) OR (neck pain) AND posture
5 children AND adolescent AND (back pain) OR (neck pain) AND (back packs) OR (school bags)
6 children AND adolescent AND (back pain) OR (neck pain) AND guidelines
7 children AND adolescent AND (back pain) OR (neck pain) AND education

PROQUEST
1 (children AND adolescents) AND spine AND pain AND guidelines
2 (children AND adolescents) AND (back pain) AND (neck pain) AND posture
3 (children and adolescents) AND exercise AND (back pain) AND (neck pain)
4 (children and adolescents) AND ergonomics AND (back pain) AND (neck pain)
5 (children and adolescents) AND physiotherapy AND (back pain) AND (neck pain)
6 (school-based) AND (spinal health) AND intervention AND children

EBSCO HOST (Cinahl)
1 "(school children) AND (back pain) OR (neck pain) AND guidelines" OR (MH "Back Pain/PC/RH/TH/NU") OR (MH "Low Back Pain/RH/TH/PC/NU")
2 "(school children) AND (back pain) OR (neck pain) OR (MH "Back Pain/PC/RH/TH/NU") OR (MH "Low Back Pain/RH/TH/PC/NU")) AND posture"
3 (MH "Neck Pain/ED/NU/PC/RH/TH") OR (MH "Back Pain/ED/NU/PC/RH/TH") OR (MH "Low Back Pain/ED/NU/PC/RH/TH") OR "(school children) AND (back pain) OR (neck pain) AND exercise"
4 (MH "Neck Pain/ED/NU/PC/RH/TH") OR (MH "Back Pain/ED/NU/PC/RH/TH") OR (MH "Low Back Pain/ED/NU/PC/RH/TH") OR "(school children) AND (back pain) OR (neck pain) AND ergonomics
5 (MH "Neck Pain/ED/NU/PC/RH/TH") OR (MH "Back Pain/ED/NU/PC/RH/TH") OR (MH "Low Back Pain/ED/NU/PC/RH/TH") OR "(school children) AND (back pain) OR (neck pain)' AND physiotherapy or (physical therapy)
6 (MH "Neck Pain/ED/NU/PC/RH/TH") OR (MH "Back Pain/ED/NU/PC/RH/TH") OR (MH "Low Back Pain/ED/NU/PC/RH/TH") OR "(school children) AND (back pain) OR (schoolbag) OR (backpack)
7 (MH "Neck Pain/ED/NU/PC/RH/TH") OR (MH "Back Pain/ED/NU/PC/RH/TH") OR (MH "Low Back Pain/ED/NU/PC/RH/TH") OR "(school children) AND (back pain) OR (neck pain) AND (school based intervention)

SCIENCE DIRECT
1 (school children) AND (back pain) OR (neck pain) AND guidelines
2 (school children) AND spine and (guidelines)

3 (school children) OR children OR adolescent) AND (back pain) OR (neck pain) AND intervention
4 (school children) OR children OR adolescent) and (back pain) OR (neck pain) AND exercise
5 (school children) OR children OR (adolescent) and (back pain) OR (neck pain) AND ergonomics
6 (school children) OR children OR (adolescent) and (back pain) OR (neck pain) AND (physical therapy) OR physiotherapy
7 (school children) OR children OR (adolescent) and (back pain) OR (neck pain) AND (posture)
8 (school children) OR children OR (adolescent) and (back pain) OR (neck pain) AND (schoolbag) or (backpack)
9 children OR adolescent AND (back pain) OR (neck pain) and (school-based) AND treatment

APPENDIX B: Journal Guidelines

The following instructions for authors are supplied online:
https://bmcpediatr.biomedcentral.com/submission-guidelines/preparing-your-manuscript

Preparing the main manuscript

General:

- Use double line spacing
- Include line and page numbering
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Abstract

The Abstract should not exceed 350 words. Please minimize the use of abbreviations and do not cite references in the abstract. The abstract must include the following separate sections:

- Background: the context and purpose of the study
- Methods: how the study was performed, and statistical tests used
- Results: the main findings
- Conclusions: summary and potential implications

Keywords

Three to ten keywords representing the main content of the article.

Background

The Background section should explain the background to the study, its aims, a summary of the existing literature and why this study was necessary or its contribution to the field.

Methods

The methods section should include:

- the aim, design and setting of the study
- the characteristics of participants or description of materials
- a clear description of all processes, interventions and comparisons. Generic drug names should generally be used. When proprietary brands are used in research, include the brand names in parentheses
- the type of statistical analysis used, including a power calculation if appropriate

Results

This should include the findings of the study including, if appropriate, results of statistical analysis which must be included either in the text or as tables and figures.

Discussion

This section should discuss the implications of the findings in context of existing research and highlight limitations of the study.

Conclusions

This should state clearly the main conclusions and provide an explanation of the importance and relevance of the study reported.

List of abbreviations

If abbreviations are used in the text they should be defined in the text at first use, and a list of abbreviations should be provided.

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All manuscripts must contain the following sections under the heading 'Declarations':

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Book chapter, or an article within a book
Wyllie AH, Kerr JFR, Currie AR. Cell death: the significance of apoptosis. In: Bourne GH, Danielli JF, Jeon KW, editors. International review of cytology. London: Academic; 1980. p. 251-306.
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Zheng L-Y, Guo X-S, He B, Sun L-J, Peng Y, Dong S-S, et al. Genome data from sweet and grain sorghum (Sorghum bicolor). GigaScience Database. 2011. http://dx.doi.org/10.5524/100012.

APPENDIX C: The PEDro scale

PEDro scale

1. eligibility criteria were specified	no ❑ yes ❑ where:
2. subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received)	no ❑ yes ❑ where:
3. allocation was concealed	no ❑ yes ❑ where:
4. the groups were similar at baseline regarding the most important prognostic indicators	no ❑ yes ❑ where:
5. there was blinding of all subjects	no ❑ yes ❑ where:
6. there was blinding of all therapists who administered the therapy	no ❑ yes ❑ where:
7. there was blinding of all assessors who measured at least one key outcome	no ❑ yes ❑ where:
8. measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups	no ❑ yes ❑ where:
9. all subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by "intention to treat"	no ❑ yes ❑ where:
10. the results of between-group statistical comparisons are reported for at least one key outcome	no ❑ yes ❑ where:
11. the study provides both point measures and measures of variability for at least one key outcome	no ❑ yes ❑ where:

The PEDro scale is based on the Delphi list developed by Verhagen and colleagues at the Department of Epidemiology, University of Maastricht (*Verhagen AP et al (1998). The Delphi list: a criteria list for quality assessment of randomised clinical trials for conducting systematic reviews developed by Delphi consensus. Journal of Clinical Epidemiology, 51(12):1235-41*). The list is based on "expert consensus" not, for the most part, on empirical data. Two additional items not on the Delphi list (PEDro scale items 8 and 10) have been included in the PEDro scale. As more empirical data comes to hand it may become possible to "weight" scale items so that the PEDro score reflects the importance of individual scale items.

The purpose of the PEDro scale is to help the users of the PEDro database rapidly identify which of the known or suspected randomised clinical trials (ie RCTs or CCTs) archived on the PEDro database are likely to be internally valid (criteria 2-9), and could have sufficient statistical information to make their results interpretable (criteria 10-11). An additional criterion (criterion 1) that relates to the external validity (or "generalisability" or "applicability" of the trial) has been retained so that the Delphi list is complete, but this criterion will not be used to calculate the PEDro score reported on the PEDro web site.

The PEDro scale should not be used as a measure of the "validity" of a study's conclusions. In particular, we caution users of the PEDro scale that studies which show significant treatment effects and which score highly on the PEDro scale do not necessarily provide evidence that the treatment is clinically useful. Additional considerations include whether the treatment effect was big enough to be clinically worthwhile, whether the positive effects of the treatment outweigh its negative effects, and the cost-effectiveness of the treatment. The scale should not be used to compare the "quality" of trials performed in different areas of therapy, primarily because it is not possible to satisfy all scale items in some areas of physiotherapy practice.

Last amended June 21st, 1999

APPENDIX C: JBI Checklist for quasi-experimental studies

THE JOANNA BRIGGS INSTITUTE

JBI Critical Appraisal Checklist for Quasi-Experimental Studies (non-randomized experimental studies)

Reviewer______________________________________Date____________________________________

Author _______________________________________Year________________Record Number______

	Yes	No	Unclear	Not applicable
1. Is it clear in the study what is the 'cause' and what is the 'effect' (i.e. there is no confusion about which variable comes first)?	☐	☐	☐	☐
2. Were the participants included in any comparisons similar?	☐	☐	☐	☐
3. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	☐	☐	☐	☐
4. Was there a control group?	☐	☐	☐	☐
5. Were there multiple measurements of the outcome both pre and post the intervention/exposure?	☐	☐	☐	☐
6. Was follow-up complete, and if not, was follow-up adequately reported and strategies to deal with loss to follow-up employed?	☐	☐	☐	☐
7. Were the outcomes of participants included in any comparisons measured in the same way?	☐	☐	☐	☐
8. Were outcomes measured in a reliable way?	☐	☐	☐	☐
9. Was appropriate statistical analysis used?	☐	☐	☐	☐

Overall appraisal: Include ☐ Exclude ☐ Seek further info ☐

Comments (Including reason for exclusion)

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