Low back pain in children and adolescents: a systematic review and meta-analysis evaluating the effectiveness of conservative interventions

Michaleff, Zoe A.; Kamper, Steven J.; Maher, Christopher G.; Evans, Roni; Broderick, Carolyn; Henschke, Nicholas

Published in:
European Spine Journal

DOI:
10.1007/s00586-014-3461-1

Low-back pain in children and adolescents: a systematic review and meta-analysis evaluating the effectiveness of conservative interventions

Zoe A Michaleff*, Steven J Kamper, Christopher G Maher, Roni Evans, Carolyn Broderick, Nicholas Henschke

ZAM – The George Institute for Global Health and Sydney Medical School, The University of Sydney, Australia, Kent Street, Sydney, 2000, Australia

SJK – EMGO+ Institute for Health and Care Research, VU University Amsterdam, The Netherlands; The George Institute for Global Health and Sydney Medical School, The University of Sydney, Australia, Kent Street, Sydney, 2000, Australia

CGM – The George Institute for Global Health and Sydney Medical School, The University of Sydney, Australia, Kent Street, Sydney, 2000, Australia

RE – Wolfe-Harris Center for Clinical Studies, Northwestern Health Sciences University, Minneapolis, USA

CB – School of Medical Sciences, UNSW Medicine, University of New South Wales, Children's Hospital Institute of Sports Medicine, Sydney Children's Hospital Network

NH – Institute of Public Health, University of Heidelberg, Heidelberg, Germany

*Corresponding author:

Zoe Michaleff

Email: zmichaleff@georgeinstitute.org.au

Word count: 3,209 words

Key words: low back pain, systematic review, children, adolescents

Abstract (word count 245)

Purpose: To identify and evaluate the effectiveness of conservative treatment approaches used in children and adolescents to manage and prevent low back pain (LBP).

Methods: Five electronic databases and the reference lists of systematic reviews were searched for relevant studies. Randomised controlled trials (RCTs) were considered eligible for inclusion if they enrolled a sample of children or adolescents (<18 years old) and evaluated the effectiveness of any conservative intervention to treat or prevent LBP. Two authors independently screened search results, extracted data, assessed risk of bias using the PEDro scale, and rated the quality of evidence using the GRADE criteria.

Results: Four RCTs on intervention and eleven RCTs on prevention of LBP were included. All included studies had a high risk of bias scoring ≤ 7 on the PEDro scale. For the treatment of LBP, a supervised exercise program compared to no treatment improved average pain intensity over the past month by 2.9 points (95%CI 1.6 to 4.1) measured by a 0-10 scale (2 studies; n=125). For the prevention of LBP, there was moderate quality evidence to suggest back education and promotion programs are not effective in reducing LBP prevalence in children and adolescents.

Conclusions: While exercise interventions appear to be promising to treat LBP in children and adolescents, there is a dearth of research data relevant to paediatric populations. Future studies conducted in children and adolescents with LBP should incorporate what has been learnt from adult LBP research and be of rigorous methodological quality.

Introduction

Low back pain (LBP) is a common and costly condition in modern society.[1] While LBP has been comprehensively researched in adults, it is only more recently that this condition has been studied in children and adolescents.[2] Epidemiological studies have reported the prevalence of LBP to be low in children (1-6%) however it rises sharply in adolescents (18-51%) to approach the prevalence of adults.[3-6] The impact of LBP on children and adolescents is significant with up to 94% of those with pain experiencing some degree of disability.[7] The direct cost to the healthcare system was estimated at a minimum of €100 million per year in Germany alone.[8] Furthermore, it has been suggested that LBP experienced during childhood and adolescence increases the risk of LBP in adulthood,[9] possibly through the development of maladaptive beliefs, behaviours, and attitudes related to the earlier pain events.[2,5]

Similarly to LBP in adults, the pathology underlying the pain in children and adolescents is not well understood and symptoms are often managed using conservative treatment approaches including exercise, massage and electrical therapies.[10] While the effectiveness of many of these conservative treatments has been evaluated for adult populations, the spine of a child and adolescent is physiologically different to the adult spine (i.e. ligamentous laxity, bone composition, muscle mass) and therefore potentially responds differently to various interventions, movements and loading.[11,12] Therefore, there is reason to evaluate the efficacy of conservative interventions for LBP in this specific patient population. Current international clinical guidelines for the management of LBP are restricted to evidence from studies performed on adult populations.[13]

Synthesis of the research regarding treatment for children and adolescents with LBP is necessary to appraise the available evidence and identify knowledge gaps. While some reviews have already been conducted,[14,15] all contain important methodological shortcomings. The aim of this systematic review was to identify and evaluate the effectiveness of conservative treatment approaches used to manage and prevent LBP in children and adolescents.

Methods

This systematic review was performed following the methods recommended by the Cochrane Back Review Group.[16] From the results of a sensitive search strategy, studies were included if they evaluated conservative interventions for children and adolescents with LBP or strategies to prevent LBP in children and adolescents.

Eligibility criteria

Randomised controlled trials (RCTs) were considered for inclusion if they enrolled a sample of children or adolescents (<18 years old). The findings were split into two sections, appraising the evidence for conservative interventions to treat LBP, or strategies to prevent LBP. A conservative intervention is defined as any non-invasive, non-surgical form of treatment.

For the intervention section, outcome measures could include pain, disability, global perceived effect or participation in daily activities. Data on other outcomes such as well-being or adverse effects were also considered and reported where possible. To be included in the prevention section, RCTs had to enrol children and adolescents with or without LBP and evaluate strategies to prevent the onset or development of LBP. Outcomes had to include

LBP intensity or back-related disability (either prevalence thereof, or mean levels across the cohort). Studies that measured cognitions or beliefs (e.g. back beliefs, knowledge regarding risk factors), or proposed risk factors (e.g. motor control, backpack usage, lifting behaviour) as an outcome were included for descriptive purposes only.

Search methods for identification of studies

Electronic databases, including the Cochrane Central Register of Controlled Trials, PubMed, EMBASE, PEDro, and CINAHL, were searched for potentially eligible studies from the earliest date up to 25th November 2013. Sensitive search strategies were designed to identify all studies on LBP related to children and adolescents (Appendix 1). In addition the reference lists of included RCTs and previous systematic reviews were searched.

Data collection and analysis

Study selection

Two authors independently reviewed all titles and abstracts identified by the electronic search to determine their potential relevance for the intervention or prevention parts of the review. Two authors also independently applied all inclusion criteria to the full text of the articles that passed the first eligibility screening. Disagreements were resolved by consensus and where necessary, by a third author.

Data extraction

Two authors independently extracted data from all eligible studies using standardised forms. Extracted data included the following: sample characteristics (participant source, mean age, gender proportions, duration of symptoms, baseline pain and disability measures); details regarding the intervention setting (e.g. tertiary pain clinic, outpatient clinic, school) and

provider type; intervention characteristics (description of index and control interventions, duration and number of sessions, individual or group delivery); co-interventions; and baseline and follow-up outcome data (e.g. pain, disability/function, adverse events). Outcomes were categorised and extracted in three groups: short-term (post treatment and not longer than 3 months), intermediate-term (6 months), and long-term (12 months or more), according to follow-up time after randomisation.

Risk of bias assessment

The PEDro scale[17,18] was used to evaluate the risk of bias in all eligible RCTs. Where available, scores for eligible trials reported on the PEDro database were used. Otherwise two authors independently scored the trial using the PEDro scale. All raters were previously trained and experienced in applying the PEDro scale. Disagreements were resolved by consensus.

Data analysis

The clinical homogeneity of RCTs was evaluated qualitatively based on the extracted data on population characteristics, intervention characteristics and outcomes measured. Statistical homogeneity was assessed by inspecting the I^2 statistic. Suitability for pooling and selection of meta-analytic model (random or fixed effects) was determined within the comparison categories based on acceptable clinical and statistical homogeneity. Forest plots were generated to present the pooled estimates where there were two or more RCTs of sufficient clinical and statistical homogeneity.

Quality of the evidence

Grades of recommendation, assessment, development and evaluation (GRADE) profiles were used to evaluate the overall quality of the evidence and the strength of the recommendations.[19] The quality of the evidence for a specific outcome was based upon five principal factors: (1) methodological limitations (for example due to RCT design), (2) inconsistency of results, (3) indirectness (affecting generalisability of the findings), (4) imprecision (e.g. sufficient data) and (5) other considerations, such as reporting bias. According to GRADE, the overall quality of evidence is considered to be high when multiple RCTs with a low risk of bias provide consistent, generalisable, and precise data for a particular outcome. The quality of the evidence was downgraded by one level for each of the factors described above that were not met.[20] Results were considered inconsistent when effect estimates were heterogeneous or only one RCT was available,[21] and quality was marked down for imprecision when fewer than 400 participants were included.[22] The following definitions of quality of the evidence were applied[23]:

- High quality: Further research is very unlikely to change our confidence in the estimate of effect;
- Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate;
- Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
- Very low quality: We are very uncertain about the estimate.

Results

The electronic search retrieved 2,466 articles (Figure 1). After screening, five articles reporting four RCTs were included in the intervention section (Tables 1 and 2) and 12 articles reporting 11 RCTs were included in the prevention section (Tables 3 and 4).

Intervention studies

Included studies

Of the four intervention RCTs (one trial by Jones *et al* reported outcomes in two articles[24,25]) included in the review,[24-28] two were conducted in the United Kingdom,[24,25,28] one in Sweden,[27] and one in South Africa.[26] Three of the four studies recruited participants from a school setting [24-26,28] with only one study recruiting participants who were care seeking [6]. Sample sizes ranged from 45 to 185 participants with a mean age range from 12 to 14.8. The duration of pain at study entry was either unrestricted or unreported in all studies. Three of the studies assessed the effectiveness of supervised exercise programs; two against a no-treatment control group[24-26] and one against a self-directed exercise program[27]. One RCT assessed the effect of a seat wedge versus a no-treatment control[28]. All RCTs measured pain intensity at follow-up, while some also collected disability, quality of life and physical measures (Table 1).

Risk of bias

The four RCTs all met between 4 and 6 criteria on the PEDro scale (Table 5). Three[26-28] reported concealed allocation and none reported an intention-to-treat analysis. Due to the nature of the interventions and the self-reported outcomes, blinding of patients, providers or assessors was not possible in any of the studies. Based on these considerations, risk of bias in all studies was considered moderate.

Effectiveness of the interventions

In two RCTs (n=125) there was a pooled mean benefit of 2.9 points on a 0-10 pain scale for average pain over the past month (95% CI 1.6 to 4.1) of a supervised exercise program over no treatment (Figure 2).[24-26] One study[26] also reported that this benefit was maintained at six month follow-up. There was no difference between groups in terms of current pain at either follow-up. Sufficient data were not available to enable pooling of other outcomes. Ahlqwist *et al*[27] reported no difference in terms of pain intensity between a supervised or a home exercise program. Candy *et al*[28] reported a statistically significant difference in short-term pain intensity in favour of a seat wedge group over no treatment.

Two RCTs measured function as an outcome; Jones *et al*[24,25] reported a reduction in absences from physical activity in favour of supervised exercise (MD (95%CI): -1.0 (-1.65, -0.35) $p<0.01$) and Ahlqwist *et al*[27] found no difference between supervised or home exercise on the Roland Morris Disability Questionnaire (MD (95%CI): -0.8 (-2.3, 0.7) $p=0.29$) (Table 2).

Secondary outcomes such as physical impairment measures (i.e. range of motion, muscle strength and endurance, flexibility) and self-reported quality of life were inconsistently measured across studies. No studies reported adverse events associated with the interventions, however one study[27] reported that some participants had to temporarily stop exercising due to pain.

Quality of the evidence - GRADE ratings

There is moderate quality evidence (downgraded due to imprecision) that in the short-term, supervised exercise programs are effective in reducing average back pain over the past month in children compared to no treatment.

There is low quality evidence (imprecision, inconsistency) that there is no effect on LBP of supervised versus unsupervised exercise programs.

There is very low quality evidence (imprecision, inconsistency, limitations in design) that a foam seat wedge reduces LBP intensity compared to no intervention; that supervised exercise programs are effective in reducing absences from physical activities, compared to no treatment; and that supervised exercise programs are not effective in reducing disability compared to home exercise programs.

Prevention studies

Included studies

Of the 11 prevention RCTs (reported in 12 articles) included in the review,[29-40] three each were conducted in Belgium,[30,31,34,35] the USA,[29,32,39] and Spain,[33,36,40] and one each in Sweden[37] and Brazil[38]. All included studies recruited participants from a school setting. The sample sizes ranged from 17 to 603 and all participants were students attending the schools chosen for inclusion in the various studies (Table 3). The mean participant age was 9 to 11 years across the studies at the time of randomisation. The majority of the studies identified in this section assessed outcomes such as back care beliefs and knowledge about posture and ergonomics, and cognitive factors such as fear avoidance and self-efficacy. Several studies also observed postural, manual handling or back-pack wearing behaviour and recorded this as an outcome (Supplementary Table 2). No studies reported adverse events associated with the interventions.

Since the focus of this part of the review was on prevention of LBP, further discussion of the results is centred on those studies that reported LBP prevalence or intensity at follow-up assessment. Only four[30,31,34,35,37] of the included prevention studies reported the effectiveness of the interventions in terms of LBP prevalence. Three studies assessed the effect of an educational and back care promotion program versus no intervention[30,31,34,35] and one study assessed the effect of providing ergonomically-designed school desks against conventional furniture.[37]

Risk of bias

The four studies all met 4 or 5 criteria on the PEDro scale (Table 6). None of the studies reported concealed allocation and none reported an intention-to-treat analysis. Due to the nature of the interventions and the self-reported outcomes, blinding of patients, providers or assessors was not possible in any of the prevention studies. Based on these considerations, risk of bias was considered to be moderate.

Effectiveness of the prevention interventions

Studies by Geldhof *et al*,[34,35] Cardon *et al*[30] and Dolphens *et al*[31] all reported no short- or long-term effect on LBP prevalence of education and back care promotion programs when compared to no treatment. Linton *et al*[37] reported a large effect of ergonomically-designed furniture, with a LBP prevalence post-intervention of 38% in the intervention group and 66% in the group that used conventional furniture. It is noted that around 50% of the students reported back pain prior to the intervention, a high figure for this age-group.

Quality of the evidence - GRADE ratings

There is moderate quality evidence (downgraded due to limitations in design) that back-related education and promotion programs are not effective in reducing LBP prevalence in children.

There is very low quality evidence (imprecision, inconsistency, limitations in design) that ergonomically-designed furniture reduces LBP prevalence compared to conventional furniture.

Discussion

Four RCTs were included in the treatment section and eleven RCTs in the prevention section of this systematic review that evaluated the effectiveness of conservative approaches to treat or prevent LBP in children and adolescents. There is moderate quality evidence to suggest that a supervised exercise intervention has a large effect on average monthly pain scores in children and adolescents compared to no treatment. There is very low quality evidence supporting the use of a foam seat wedge for the treatment of LBP in children. For the prevention of LBP, there is moderate quality evidence to suggest that back-related education and back care promotion programs are not effective in preventing LBP in children and adolescents. There is also very low quality evidence supporting the use of ergonomically-designed furniture over conventional furniture. There are conflicting results for the treatment and prevention of LBP when considering measures beyond pain and disability e.g. physical measures in intervention studies and observed behaviour, physical measures, and knowledge tests in prevention studies.

The findings of this review are somewhat consistent with previous systematic reviews that report on the effectiveness of treatment and prevention interventions for LBP in children and

adolescents.[14,15] The strengths of this systematic review and meta-analysis are that it was conducted in accordance with the methods recommended by the Cochrane Back Review Group,[16] focused on clinically meaningful outcome measures of pain and disability, and used a sensitive search strategy which limits the likelihood any relevant studies have been missed. Only RCTs were eligible for inclusion in this review as this methodology provides the most reliable form of evidence when evaluating treatment effectiveness. The methodological quality of included studies was assessed using the PEDro scale, a rigorously developed[41] and evaluated risk of bias tool that is both valid and reliable;[17,18] and the strength of recommendations reported in accordance with GRADE guidelines. Lastly, only studies that demonstrated sufficient clinical and statistical homogeneity were pooled in the meta-analysis.

The limitations of this review include the small number of primary treatment and prevention studies and large heterogeneity between studies that prevented the pooling of results in the meta-analysis for all but one comparison. The inability to pool results means that the findings of this review are based on individual studies; as such it is not possible for robust conclusions to be made. Newly conducted, high quality research is likely to have a large influence on our understanding of the effectiveness of interventions to treat and prevent LBP in children and adolescents. Future studies need to carefully consider the methodological issues known to influence internal and external validity. The issue of generalisability is of particular relevance in this field given that study participants are often recruited from schools, as opposed to from care-providers. This choice of sampling frame has unknown implications for the estimate of treatment effectiveness.[42] Furthermore, limitations in the reporting of studies included in the intervention section of this review (e.g. no study reported the duration of pain at study entry) negatively impacts on the generalisability and applicability of the results.

Compared to adult populations, the effectiveness of exercise treatment programs in children appears to have a greater effect on pain however a similar effect on function. Hayden *et al*[43] found no difference in short-term pain relief or function between exercise therapy and no treatment for adults with acute LBP and insufficient evidence for the use of exercise in the sub-acute phase. For adults with chronic LBP, exercise therapy appears to be minimally effective at decreasing pain (7.29 points on a 0-100 scale) and improving function (2.50 points on a 0-100).[43] Our review found a large mean benefit for a supervised exercise program over no treatment for average pain over the last month (2.9 points on a 0-10 pain scale for average pain over the past month). Despite the observed effect on *average* pain, there was no effect on *current* pain or function so this discrepancy reduces our confidence in the effect reported. As mentioned above, the robustness of the comparison between children and adults is compromised due to included studies not reporting the duration of low back pain symptoms experienced by the children enrolled. In keeping with the findings of the current review the use of education and back care promotion programs have not been recommended to prevent the onset of LBP in adult populations[13] and there is no robust evidence to support the use of ergonomic furniture.

This review has a number of important implications for clinical practice and future research in the area of child and adolescent LBP. Low back pain research conducted in children and adolescents is an emerging area when compared to the volume of research that has been conducted in adult populations. The four intervention RCTs included in this review can be compared to the several hundred conducted in adult populations.[13] This situation provides a unique opportunity to reflect and learn from the work that has been done in adult populations and apply this knowledge and skill to a new population.[44] In particular, there is

a need for large, high quality RCTs to guide clinicians treating children and adolescents with LBP and inform the development of evidence-base health promotion programs targeting the prevention of spinal pain. There is a need to use psychometrically sound, clinically meaningful and standardised outcome measures for pain, function, health care utilisation and physical activity, as this will increase the clinical applicability of the research and facilitate the pooling of RCT results.[44] The infancy of this research area provides an opportunity to use alternative research methods (e.g. qualitative methods) to identify outcomes that are most important to patients and their family caregivers and highlights the need for detailed and systematic data collection including duration of LBP and adverse events. Lastly, while the prevention of LBP could prove to be a major advance in musculoskeletal research there is a need to improve our understanding of the causative mechanisms of LBP to facilitate the development and evaluation of targeted treatment and prevention interventions.

Conflict of interest

None of the authors involved in the preparation of this manuscript have any potential, perceived or real conflict to disclose.

Table 1: Characteristics of included treatment RCTs

Study	Setting	Participants	Interventions	Follow-up
Jones et al 2007[24,25]	United Kingdom; 2 secondary schools	N=62 Males: 50% Mean age (SD): 14.6 (0.6)	Exercise rehabilitation: strength, flexibility and aerobic exercise; 2 x 30 min sessions for 8 weeks. Control: no treatment	Post-intervention: 2 months
Fanucchi et al 2009[26]	South Africa; 2 government primary schools	N=72 Males: 54.2% Mean age (SD): 12 (0.7)	Exercise classes: delivered by physiotherapist; 1 x 40-45 min class during school hours for 8 weeks plus a home exercise program. Control: no treatment	Post-intervention: 3 months Follow-up: 6 months
Ahlqwist et al 2008[27]	Sweden; Patients referred to physiotherapy	N=45 Males: 33.3% Mean age (SD): 14.5 (1.5)	Individualised physical therapy and self-training: twice a week for 12 weeks, once a week supervised by a physical therapist. Conditioning, mobility, strength and coordination. Self-Training: 3 x ≥20 min sessions per week for 12 weeks.	Post-intervention: 3 months
Candy et al 2012[28]	United Kingdom; 12 secondary schools	N=185 Males: 21.6% Mean age (SD): 14.8 (0.7)	Seat wedge: high density foam wedge on the seat surface with a 10 degree forward inclination. Students used wedge on their school seats for 3 weeks. Control: no treatment	Post-intervention: 1 month

Table 2: Results of included treatment RCTs

Study	Intervention (n)	Pain (0-10 scale)		Disability
		Short term	Medium term	Short term
Jones et al 2007[24,25]	Exercise Bsl (n=31); Post (n=31) No treatment Bsl (n=31); Post (n=29)	MD (95%CI): -3.50 (-4.67, -2.33) p<0.001 (in favour of exercise)		Absences from physical activity: MD (95%CI): -1.0 (-1.65, -0.35) p<0.01 (in favour of exercise)
Fanucchi et al 2009[26]	Exercise Bsl (n=39); Post (n=39); Follow up 6 months (n=38) No treatment Bsl (n=33); Post (n=32); Follow up 6 months (n=32)	Pain over past month: MD (95%CI): -2.20 (-3.46, -0.94) p<0.01 (in favour of exercise) Current pain: MD (95%CI): -1.2 (-2.57, 0.17) p=0.09 LBP prevalence: RD (95%CI): 0.24 (0.04, 0.41) p<0.01 (in favour of exercise)	Pain over past month: MD (95%CI): -2.00 (-3.46, -0.54) p=0.01 (in favour of exercise) Current pain: MD (95%CI): 0.3 (-1.27, 1.87) p=0.7 LBP prevalence: RD (95%CI): 0.40 (0.18, 0.57) p<0.001 (in favour of exercise)	
Ahlqwist et al 2008[27]	Individualised therapy and self-training Bsl (n=23); Post (n=23) Self-training (n=22) Bsl (n=22); Post (n=22)	MD (95%CI): -0.5 (-1.3, 0.3) p=0.22		Disability (RMDQ): MD (95%CI): -0.8 (-2.3, 0.7) p=0.29
Candy et al 2012[28]	Seat wedge (n=93) Bsl (n=93); Post (n=51) No treatment (n=92) Bsl (n=92); Post (n46)	Average (95%CI) reduction was 0.013 (-0.025, -0.001) points per half day in the intervention group compared to the control group p=0.036		

Bsl: Baseline; Post: post-treatment; VAS: visual analogue scale; MD: mean difference; RD: risk difference; RMDQ: Roland-Morris Disability Questionnaire; NRS: numerical rating scale; CI: confidence interval

Table 3: Characteristics of included prevention RCTs

Study	Setting	Participants	Interventions	Follow-up
Linton et al 1994[37]	Sweden Grade schools	N=67 Males: 52.2% Mean age: 9.9	Ergonomically designed desks Traditional furniture	Post-intervention: 6 months Follow-up: 5 months
Geldhof et al 2006/7[34,35]	Belgium Elementary schools	N=398 Males: 44.0% Mean age (SD): 11.3 (0.8)	Multi-factorial back education program, including back education once a week for 6 weeks delivered by a physiotherapist and reinforced by teachers; modification of the environment and utilisation of ergonomic supports No intervention	Post-intervention: 18 months Follow-up: 12 and 24 months
Cardon et al 2007[30]	Belgium Public schools	N=603 Males: 47.9% Mean age (SD): 9.7 (0.7)	Back education session once a week for 6 weeks delivered by a physiotherapist Back education session once a week for 6 weeks delivered by a physiotherapist, plus physical activity promotion session 1x/ week for 6 weeks and extra-curricular sports session once a week from a physical education specialist No intervention	Post-intervention: 18 months
Dolphens et al 2011[31]	Belgium Elementary schools	N=363 Males: not reported Mean age (SD): range 9 and 11 years	Back care promotion program 1x/ week for 6 weeks run by a physiotherapist No intervention	Post-intervention: 1 week Follow-up: 1 and 8 years
Spence et al 1984[39]	USA Elementary	N= 76 Males: not reported	Demonstration of lifting techniques with 5 min video and 5 min review of major principles	Post intervention: 1 week Follow up: 2 months

	schools	Mean age: not reported	Guided discovery: 15 min interactive session No treatment	
Gallardo Vidal et al 2012[33]	Spain Public schools	N=357 Males: 46.5% Mean age: 9	Educational intervention by a physiotherapist on backpack weight No treatment	Post intervention: immediately after education intervention (Intervention group only) Follow up: 3 months
Feingold et al 2002[32]	USA Middle school students	N=17 Males: 47.1% Mean age: 12.7	30 minute educational video and hands-on session in which participants learned to load, lift and wear back packs properly No treatment	Post intervention: 2 weeks
Bauer et al 2009[29]	USA Middle school students	N=20 Males: 50% Mean age (SD): 12.9 (1.0)	Additional comfort backpack with air padded 'S' shaped shoulder straps and lumbar support, side compression straps and padded haul bar Backpack with standard features, straight cut padded shoulder straps and back	Post intervention: same day as testing
Kovacs et al 2011[36]	Spain Primary school	N= 574 Males: 43% Mean age: 8 (-)	Written educational booklet '*Comic book of the back'* No intervention	Post intervention: 1 week Follow-up: 3 months
Moreira et al 2012[38]	Brazil State schools	N=80 Males: 51.7% Mean age (SD): 12.1 (1.95)	Exercise program 1 hour, 2x/ week for 6 weeks. Running warm up, low back stability exercises and stretching. No intervention	Post intervention: 6 weeks
Vidal et al	Spain	N=145	Postural education program for 1 hour, 1x/ week	Post intervention: 6 weeks

2013[40]	Primary schools	Males: not reported Mean age (SD): 10.7 (0.67)	for 6 weeks (4 theoretical and 2 practical sessions) No intervention	Follow-up: 3 months

Table 4: Results of included prevention studies

Study	Intervention (n=)	Pain prevalence		
		Baseline	**Short term**	**Long term**
Linton et al 1994[37]	1. Ergonomically desks Bsl (n=46); Post (n=NR); 5 months (n= NR) 2. Traditional furniture Bsl (n=21); Post (n= NR); 5 months (n= NR)	Group 1: 50% Group 2: 54% (in favour of the ergonomic group)	Group 1: 41% Group 2: 72% (in favour of the ergonomic group)	Group 1: 38% Group 2: 66% p< 0.04 (in favour of the ergonomic group)
Geldhof et al 2006/7[34,35]	1. Multi-factorial education Bsl (n=213); Post (n=193); 2 year follow up (n=186) 2. No intervention Bsl (n=185); Post (n=172); 2 year follow up (n=167)	Group 1: 31% Group 2: 31% No difference between groups	Group 1: 29% Group 2: 32% No difference between groups	2 years: Group 1: 20% Group 2: 23% No difference between groups
Cardon et al 2007[30]	1. Back care promotion Bsl (n=213); Post (n=173) 2. Back care and physical activity Bsl (n=205); Post (n=175) 3. No intervention Bsl (n=185); Post (n=159)	Group 1: 31% Group 2: 28% Group 3: 31% No difference between groups	Group 1: 30% Group 2: 27% Group 3: 34% No difference between groups	
Dolphens et al 2011[31]	1. Back care promotion Bsl (n=198); Post (n=196); 8 year follow up (n=96) 2. No intervention Bsl (n=165); Post (n=165) 8 year follow up (n=98)	Group 1: 34.4% Group 2: 19.4% No difference between groups	Group 1: 29.8% Group 2: 20.6% No difference between groups	1 year: Group 1: 27.7% Group 2: 16.7% No difference between groups 8 years: Group 1: 54.2% Group 2: 41.8%

				No difference between groups

Bsl: Baseline; Post: post-treatment; NR: Not reported

Figure 2. Pooled post-treatment effect on average pain over the past month of supervised exercise programs versus no treatment for children with LBP

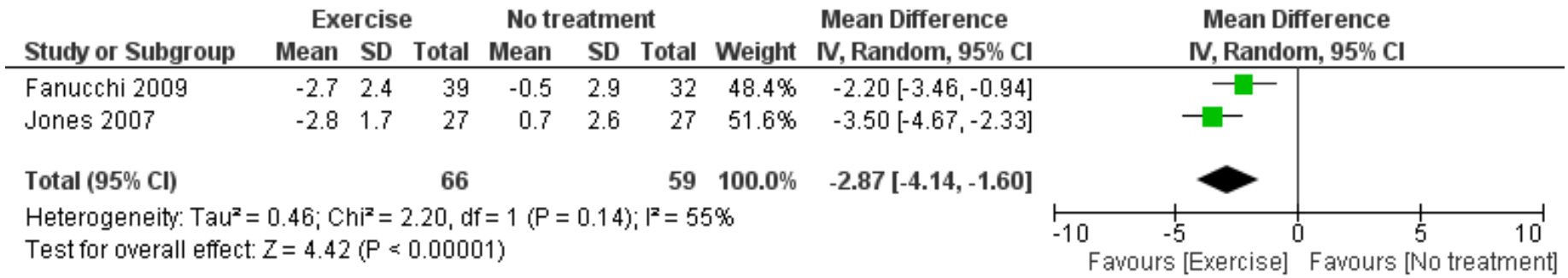


Table 5: PEDro scale for included treatment RCTs

Study	Eligibility criteria	Random allocation	Concealed allocation	Baseline comparability	Blind subjects	Blind therapists	Blind assessors	Adequate follow-up	Intention-to-treat analysis	Between-group comparisons	Point estimates and variability	PEDro score* (/10)
Jones et al 2007a[24]	Yes	Yes	No	No	No	No	No	Yes	No	Yes	Yes	4
Jones et al 2007b[25]	No	Yes	No	Yes	No	No	No	Yes	No	Yes	Yes	5
Fanucchi et al 2009[26]	Yes	Yes	Yes	Yes	No	No	No	Yes	No	Yes	Yes	6
Ahlqwist et al 2008[27]	Yes	Yes	Yes	Yes	No	No	No	Yes	No	Yes	Yes	6
Candy et al 2012[28]	Yes	Yes	Yes	Yes	No	No	No	No	No	Yes	Yes	5

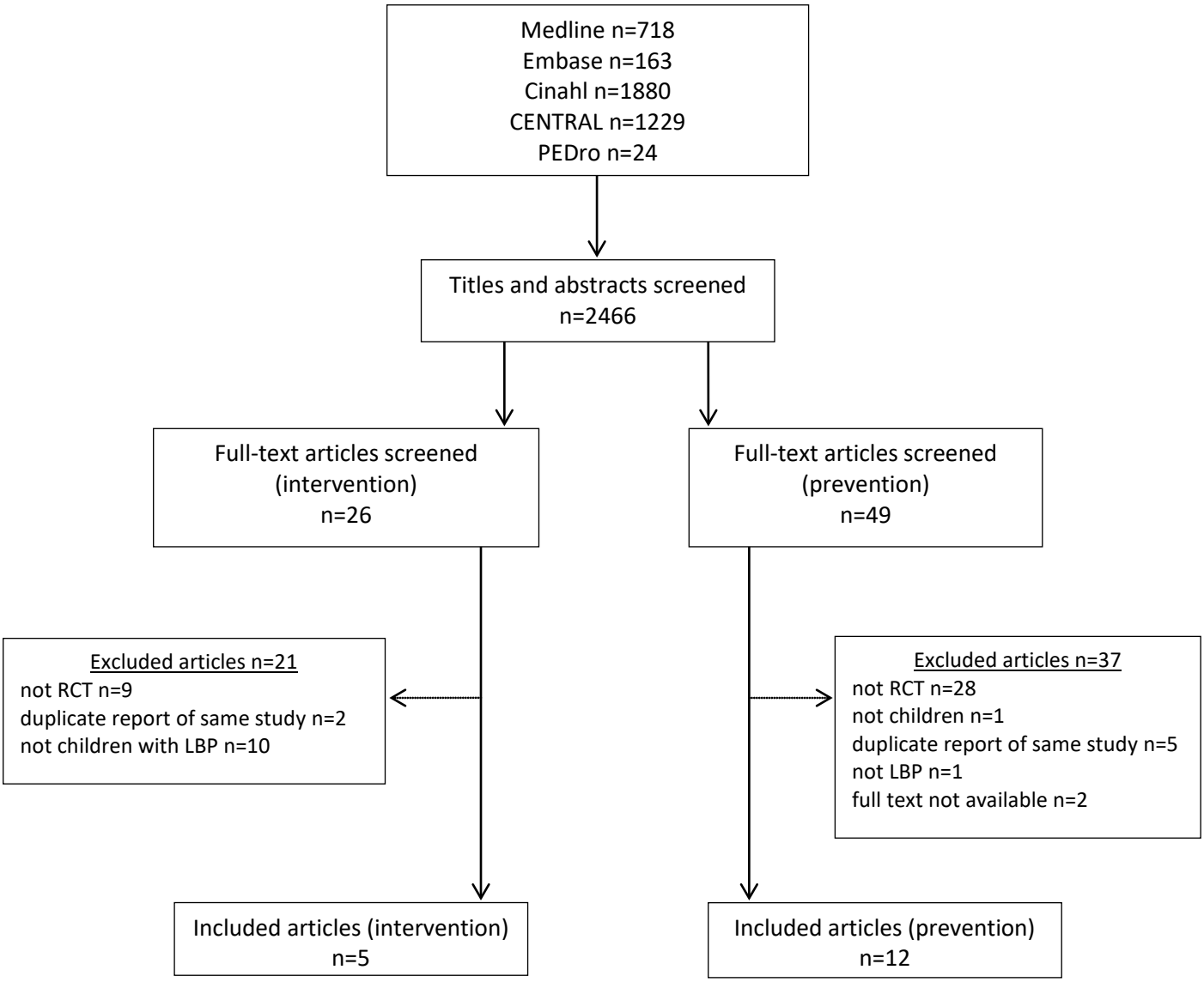
*PEDro score includes one point for each criteria fulfilled, except for “Eligibility criteria”.

Table 6: PEDro scale for included prevention RCTs

Study	Eligibility criteria	Random allocation	Concealed allocation	Baseline comparability	Blind subjects	Blind therapists	Blind assessors	Adequate follow-up	Intention-to-treat analysis	Between-group comparisons	Point estimates and variability	PEDro score* (/10)
Linton et al 1994[37]	Yes	Yes	No	Yes	Yes	No	No	Yes	No	Yes	No	5
Geldhof et al 2006[34]	No	Yes	No	Yes	No	No	No	Yes	No	Yes	Yes	5
Geldhof et al 2007[35]	No	Yes	No	Yes	No	No	No	No	No	Yes	Yes	4
Cardon et al 2007[30]	No	Yes	No	No	No	No	Yes	Yes	No	Yes	Yes	5
Dolphens et al 2011[31]	No	Yes	No	Yes	No	No	No	Yes	No	Yes	Yes	5
Spence et al 1984[39]	No	Yes	No	No	No	No	No	Yes	No	Yes	Yes	4
Gallardo Vidal et al 2012[33]	Yes	Yes	Yes	Yes	No	No	No	Yes	No	Yes	Yes	7
Feingold et al 2002[32]	No	Yes	No	No	No	No	No	No	No	Yes	No	2
Bauer et al 2009[29]	No	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	6
Kovacs et al 2011[36]	Yes	Yes	Yes	No	No	No	Yes	Yes	No	Yes	Yes	6
Moreira et al 2012[38]	Yes	Yes	No	Yes	No	No	No	No	No	Yes	Yes	4
Vidal et al 2013[40]	Yes	Yes	No	Yes	No	No	No	Yes	No	Yes	Yes	5

*PEDro score includes one point for each criteria fulfilled, except for “Eligibility criteria”.

Figure 1. Flowchart of search strategy



References:

1. Woolf A, Pfleger B (2003) Burden of major musculoskeletal conditions. Bulletin of the World Health Organization 81:646-656.

2. Jeffries L, Milanese S, Grimmer-Somers K (2007) Epidemiology of Adolescent Spinal Pain A Systematic Overview of the Research Literature. Spine 32:2630-2637.

3. Briggs A, Buchbinder R (2009) Back pain: a National Health Priority Area in Australia? Medical Journal of Australia 190:499-502.

4. Balagué F et al. (1995) Low back pain in schoolchildren: A study of familial and psychological factors. Spine 20:1265-1270.

5. Taimela S et al. (1997) The Prevalence of Low Back Pain Among Children and Adolescents: A Nationwide, Cohort-Based Questionnaire Survey in Finland. Spine 22:1132-1136.

6. King S et al. (2011) The epidemiology of chronic pain in children and adolescents revisited: a systematic review. Pain 152:2729-2738.

7. Watson K et al. (2002) Low back pain in schoolchildren: occurrence and characteristics. Pain 97:87-92.

8. Ochsmann E et al. (2010) Prevalence of diagnosis and direct treatment costs of back disorders in 644,773 children and youths in Germany. BMC Musculoskeletal Disorders 11:193.

9. Hestbaek L, Leboeuf-Yde C, Kyvik K (2006) Are lifestyle-factors in adolescence predictors for adult low back pain? A cross-sectional and prospective study of young twins. BMC Musculoskeletal Disorders 7:27.

10. Kosseim M, Rein R, McShane C (2008) Implementing Evidence-Based Physiotherapy Practice for Treating Children with Low Back Pain: Are We There Yet? Pediatric Physical Therapy 20:179-184.

11. Jebaseelan DD et al. (2012) Sensitivity studies of pediatric material properties on juvenile lumbar spine responses using finite element analysis. Medical & biological engineering & computing 50:515-522.

12. Junewick JJ (2010) Cervical spine injuries in pediatrics: are children small adults or not? Pediatric radiology 40:493-498.

13. Koes BW et al. (2010) An updated overview of clinical guidelines for the management of non-specific low back pain in primary care. Eur Spine J 19:2075-2094.

14. Steele EJ, Dawson AP, Hiller JE (2006) School-based interventions for spinal pain: a systematic review. Spine (Phila Pa 1976) 31:226-233.

15. Calvo-Munoz I, Gomez-Conesa A, Sanchez-Meca J (2013) Physical therapy treatments for low back pain in children and adolescents: a meta-analysis. BMC Musculoskelet Disord 14:55.

16. Furlan AD et al. (2009) 2009 updated method guidelines for systematic reviews in the Cochrane Back Review Group. Spine 34:1929-1941.

17. Macedo LG et al. (2010) There was evidence of convergent and construct validity of Physiotherapy Evidence Database quality scale for physiotherapy trials. Journal of Clinical Epidemiology 63:920-925.

18. Maher CG et al. (2003) Reliability of the PEDro scale for rating quality of randomized controlled trials. Physical Therapy 83:713-721.

19. Atkins D et al. (2004) Grading quality of evidence and strength of recommendations. BMJ 328:1490.

20. Adams R et al. (2002) Recommendations for improving the quality of care through stroke centers and systems: an examination of stroke center identification options: multidisciplinary consensus recommendations from the Advisory Working Group on Stroke Center Identification Options of the American Stroke Association. Stroke 33:e1-7.

21. Henschke N et al. (2010) Behavioural treatment for chronic low-back pain. Cochrane Database SystRev 7:CD002014.

22. Guyatt GH et al. (2011) GRADE guidelines 6. Rating the quality of evidence--imprecision. J Clin Epidemiol 64:1283-1293.

23. Guyatt GH et al. (2008) Rating quality of evidence and strength of recommendations: GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. BMJ: British Medical Journal 336:924.

24. Jones M et al. (2007) The efficacy of exercise as an intervention to treat recurrent nonspecific low back pain in adolescents. Pediatr Exerc Sci 19:349-359.

25. Jones MA et al. (2007) Recurrent non-specific low-back pain in adolescents: the role of exercise. Ergonomics 50:1680-1688.

26. Fanucchi GL et al. (2009) Exercise reduces the intensity and prevalence of low back pain in 12-13 year old children: a randomised trial. Aust J Physiother 55:97-104.

27. Ahlqwist A et al. (2008) Physical therapy treatment of back complaints on children and adolescents. Spine (Phila Pa 1976) 33:E721-727.

28. Candy EA et al. (2012) 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. Physiotherapy 98:301-306.

29. Bauer DH, Freivalds A (2009) Backpack load limit recommendation for middle school students based on physiological and psychophysical measurements. Work 32:339-350.

30. Cardon GM et al. (2007) Back education in elementary schoolchildren: the effects of adding a physical activity promotion program to a back care program. Eur Spine J 16:125-133.

31. Dolphens M et al. (2011) Long-term effectiveness of a back education programme in elementary schoolchildren: an 8-year follow-up study. Eur Spine J 20:2134-2142.

32. Feingold AJ, Jacobs K (2002) The effect of education on backpack wearing and posture in a middle school population. Work 18:287-294.

33. Gallardo Vidal M, Rodríguez Barrientos R, Borda Olivas A (2012) Evaluación de la efectividad de una intervención educativa para disminuir el peso de la mochila escolar en los alumnos de 3. y 4. de educación primaria. Fisioterapia.

34. Geldhof E et al. (2006) Effects of a two-school-year multifactorial back education program in elementary schoolchildren. Spine (Phila Pa 1976) 31:1965-1973.

35. Geldhof E et al. (2007) Back posture education in elementary schoolchildren: a 2-year follow-up study. Eur Spine J 16:841-850.

36. Kovacs F et al. (2011) Improving schoolchildren's knowledge of methods for the prevention and management of low back pain: a cluster randomized controlled trial. Spine (Phila Pa 1976) 36:E505-512.

37. Linton SJ et al. (1994) The effects of ergonomically designed school furniture on pupils' attitudes, symptoms and behaviour. Appl Ergon 25:299-304.

38. Moreira RF et al. (2012) Effects of a school based exercise program on children's resistance and flexibility. Work 41 Suppl 1:922-928.

39. Spence SM, Jensen GM, Shepard KF (1984) Comparison of methods of teaching children proper lifting techniques. Phys Ther 64:1055-1061.

40. Vidal J et al. (2013) Effects of a postural education program on school backpack habits related to low back pain in children. Eur Spine J 22:782-787.

41. Verhagen AP et al. (1998) The Delphi List: A Criteria List for Quality Assessment of Randomized Clinical Trials for Conducting Systematic Reviews Developed by Delphi Consensus. Journal of Clinical Epidemiology 51:1235-1241.

42. Jüni P, Altman DG, Egger M (2001) Systematic reviews in health care: Assessing the quality of controlled clinical trials. BMJ: British Medical Journal 323:42.

43. Hayden JA et al. (2005) Meta-analysis: exercise therapy for nonspecific low back pain. Annals of Internal Medicine 142:765-775.

44. McGrath PJ et al. (2008) Core outcome domains and measures for pediatric acute and chronic/recurrent pain clinical trials: PedIMMPACT recommendations. The Journal of Pain 9:771-783.

Appendix 1

Example search strategy for MEDLINE (OVID). The search terms were modified slightly for other databases. These are available on request from the authors.

Part A: Generic search for randomized controlled trials and controlled clinical trials
1. randomized controlled trial.pt.
2. controlled clinical trial.pt.
3. comparative study.pt.
4. clinical trial.pt.
5. randomized.ab.
6. placebo.ab,ti.
7. drug therapy.fs.
8. randomly.ab,ti.
9. trial.ab,ti.
10. groups.ab,ti.
11. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10
12. (animals not (humans and animals)).sh.
13. 11 not 12

Part B: Specific search for thoracic, low back, sacrum and coccyx problems
14. dorsalgia.ti,ab.
15. exp Back Pain/
16. backache.ti,ab.
17. exp Low Back Pain/
18. (lumbar adj pain).ti,ab.
19. coccyx.ti,ab.
20. coccydynia.ti,ab.
21. sciatica.ti,ab.
22. sciatic neuropathy/
23. spondylosis.ti,ab.
24. lumbago.ti,ab.
25. back disorder$.ti,ab.
26. or/14-25
Part C: Sensitive search for children and adolescents
27. child$.ti,ab.
28. adolesce$.ti,ab.
29. youth$.ti,ab.
30. school$.ti,ab.
31. student$.ti,ab.
32. teena$.ti,ab.
33. young.ti,ab.
34. 27 or 28 or 29 or 30 or 31 or 32 or 33

Part D: Combined search
35. 13 AND 26 AND 34