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REVIEW

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Low back pain prevention's effects in schoolchildren. What is the evidence?

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Abstract Given the high prevalence rates of back pain, as early as in childhood, there has been a call for early preventive interventions. To determine which interventions are used to prevent back problems in schoolchildren, as well as what the evidence is for their utility, the literature was searched to locate all investigations that used subjects under the age of 18 and not seeking treatment. Included investigations were specifically designed as an intervention for low back pain (LBP) prevention. Additionally, a literature search was performed for modifiable risk factors for LBP in schoolchildren. The literature-update search was performed within the scope of the "COST Action B13" of the European Commission, approved for the development of European guidelines for the management of LBP. It was concluded that intervention studies in schoolchildren focusing on back-pain prevention are promising but too limited to formulate evidence-based guidelines. On the other hand, since the literature shows that back-pain reports about schoolchildren are mainly associated with psychosocial factors, the scope for LBP prevention in schoolchildren may be limited. However, schoolchildren are receptive to back-care-related knowledge and postural habits, which may play a preventive role for back pain in adulthood. Further studies with a follow-up into adulthood are needed to evaluate the long-term effect of early interventions and the possible detrimental effect of spinal loading at young age.

Keywords Non-specific low back pain · Prevention · Risk factors · Schoolchildren

Introduction

Low back pain (LBP) was traditionally reported to be uncommon in children. Moreover, it was believed that this symptom was almost always due to a serious underlying illness. During recent decades, particularly since the publication of the thesis of Salminen in 1984 [58], an increasingly large number of surveys have demonstrated that non-specific LBP in schoolchildren is much more frequent than thought in the past [2, 7, 39, 45, 59, 70]. Simultaneously, various surveys have been published reporting factors associated with, or predisposing to, LBP. The methodological quality of the studies has improved progressively over time and is recently moving from cross-sectional studies, only allowing obtaining figures of prevalence and associated factors, to longitudinal studies reporting incidence and causal relationship. Furthermore, clinical and epidemiological data, analysis of risk factors, MRI and immunohistological findings draw attention to the early degenerative changes of the spine and to the usefulness of precocious prevention [54, 61]. In addition, there is growing evidence that back pain at young age has a predictive value on LBP as an adult [1, 28, 61]. As a result, the epidemiological surveys have been followed by interventions targeting primary prevention in LBP.

Various approaches have been used to prevent LBP in schoolchildren. A majority of these studies could be grouped under the label "education," because the interventions consisted of a variable number of hours of education with or without associated exercises. Some authors had a very limited target, such as lifting technique [56, 63, 66], while others aimed at reducing LBP and its consequences [4, 13, 15, 49, 68, 72]. It has been demonstrated that various interventions successfully improved specific back-care-related knowledge and/or skills [12, 13, 49, 72]. However, this is not synonymous with prevention in LBP. There have also been attempts to prevent LBP by modifications of the school furniture [31, 35]. However, no high quality study to test the possible protective effect of furniture could be located. A third approach could be focusing on modifiable risk factors (e.g., smoking). However, since primary causative mechanisms for common LBP remain largely undetermined, caution should be exercised in considering risk factor modification as prevention, without evidence of influence on LBP outcomes.

To increase consistency in the management of non-specific LBP across countries in Europe, the European Commission Research Directorate General approved a program for the development of European guidelines for the management of LBP, called "COST Action B13" [18]. The COST program of the European Commission stimulates and co-ordinates European collaboration in the field of scientific and technical research, with the aim of establishing networks of researchers across Europe. Typically, COST actions have several working groups (WG); thus, within the COST B13 action:

- WG 1 focuses on diagnosis and treatment of acute LBP
- WG 2 focuses on diagnosis and treatment of chronic LBP
- WG 3 focuses on prevention of LBP and is composed of three subgroups aiming respectively at the general population, the workforce and schoolchildren
- WG 4 focuses on pelvic pain

The WG 3 searches evaluate not only the effects that preventive interventions have on back pain prevalence but also on the effects the interventions have on back-pain-related consequences. The present review paper is the result of a literature search performed for the COST B13 action by a subgroup of WG 3 members, focusing on LBP prevention's effects in schoolchildren.

Methods

WG 3 anticipated that the field of prevention was likely lacking in scientific evidence, which would present difficulties for acquisition and assessment of appropriate literature. A full, systematic review methodology in such a multidisciplinary field would be impracticable and inappropriate. Moreover, a full systematic review was not feasible within the frame of this project. Thus, in order to achieve the aim of providing guidance, the literature search was undertaken on a somewhat open basis, and the subsequent evidence grading was also rather more open than is usual for clinical guidelines. Moreover, due to the limited number of studies evaluating the effects of preventive intervention in schoolchildren, WG 3 decided to include a search for modifiable risk factors for LBP in schoolchildren.

An electronic search on Pub Med for articles published since 1995 was performed by two independent researchers, making use of the following keywords: children OR adolescents AND back pain AND adipos* / anthropometr* / attention / awareness / back pack / back school / behavior* / body mechan* / competit* / computer / depress* / educat* / environment* / exercise* / famil* / flexibility / furniture /health / job* / laptop / leg inequality / leg length / leisure time / manual handling /medical attention / muscle / obes* / overweight / performance / pezzi balls / physical activ* / postur* / prevent* / promot* / psychol* / satchel / school achievement / schoolbag / screen / sitting / smok* / sports / strength / stress / therap* / tight* / tobacco / treatment / TV / videogames / work*.

Non-English manuscripts without an English abstract were not considered for inclusion. The database research was supplemented by citation tracking, personal databases and expert knowledge. Both researchers independently reviewed the studies and excluded manuscripts limited to specific back pain (e.g., LBP attributed to infection, tumour, fracture or ankylosing spondylitis) and non-modifiable risk factors, such as age, gender, anthropometrics, parental-educational level and demographic factors. Also, studies with only epidemiological data, studies not focusing on back pain or possible consequences of back pain and studies without data for children under the age of 18 were excluded for the present review.

The review of the literature may be summarised as systematic searching of the published scientific literature with a mixed quantitative/qualitative evaluation of the consistency and relevance of the evidence to produce recommendations based on a best synthesis.

Results

The electronic search resulted in 1,124 hits for the period between 1 January 1995 and 30 September 2003. After exclusion of duplicate and irrelevant studies, a total of five studies were included for the review of preventive interventions (see Table 1) and 44 studies for the review of modifiable risk factors (see Table 2).

Intervention studies

In schoolchildren, only five intervention studies, including the evaluation of back pain or the consequences of back pain, could be located in the literature since 1995. Balagué et al. [4], Mendez et al. [49], Cardon et al. [13], Feingold and Jacobs [19] and Storr-Paulsen [68] all evaluated a school-based intervention program consisting of a variable number of hours of education. In the study by Balagué et al. [4], a rheumatologist trained 55 primary-school teachers in the use of Swedish back school, during two sessions of 90 min plus an annual 2 h session. Back school was then administered by the primary-school teachers over a 3-year period. Effects of the program were evaluated through a pre-post intervention survey. The post-intervention survey included 1,715 elementary schoolchildren. The program implementation resulted in an overall reduction in prevalence of LBP during the 3-year period analysed. Recollection of participation in the prevention

Table 1 Overview of intervention studies for LBP prevention in schoolchildren, including type of article, description of the evaluated intervention, specific outcomes and original authors' main conclusions

Authors	Type of article Number (*n*) Mean age (years)	Description of intervention	Specific outcomes	Original authors' main conclusions
Balagué et al., 1996 [3]	Original study *n*: 1,716 Age: 11.7	A rheumatologist trained 55 primary-school teachers in the use of Swedish back school, during two sessions of 90 min plus an annual 2 h session. The teachers then administered back school over a 3-year period	– 60% of the children did not recall the back school – Only one-fifth to one-third of the teachers daily integrated the back-school concept into their teaching – During the 3-year period, there was an overall reduction in prevalence of LBP and a small-but-significant reduction in perceived disability – Pupils' recollection of participation was associated with increased LBP prevalence ($p<0.001$) and reduction in the utilisation of medical care for LBP ($p<0.05$)	Introducing a back program in primary-school teacher education would allow integration of the concepts of prophylaxis and enhance a positive attitude toward prevention, with the merit of demedicalising LBP
Cardon et al., 2002 [13]	Original study *n*:696 (intervention: 347, control: 349) Age: 10.0	A back education program (six 60-min sessions at 1-week intervals) was implemented by a physical therapist (PT) for elementary school pupils, through guided discovery and hands-on methods	Program resulted in lower self-reported back- and neck-pain prevalence (*N*: 347) ($p<0.05$) and better use of many back-care principles, evaluated in a practical test (*N*: 198) and with a candid camera evaluation (*N*: 38) ($p<0.001$) after the program and 3 and 9 months later	Back education in elementary schoolchildren is efficacious up to 1 year. Implementation of early back education in the school timetable is advocated
Feingold and Jacobs, 2002 [18]	Original study *n*: 17 (intervention: 9, control: 8) Age: 12.7	Pupils were shown a 30-min presentation in which they were taught the importance of proper wearing of a backpack, followed by hands-on practice guided by the instructor	– Education assisted by video analyses was found to have no effect on children's backpack-wearing posture – 2 participants reported less pain in their back; 4 reported less pressure and pain on the shoulders and one reported less strain in her neck	Education regarding proper wearing of a backpack may impact the middle-school-aged child by improving quality of life, as indicated by decrease in reports of musculoskeletal pain by participants
Mendez and Gomez-Conesa, 2001 [48]	Original study *n*: 106 (intervention: 35, control: 36, placebo: 35) Age: 9	Postural hygiene program consisting of 11 sessions (three devoted to physiotherapy exercises, eight to behaviour intervention, for total of 19 hours)	– Level of knowledge and motor skills increased significantly after program completion and at 6-month and 12-month follow-up ($p=0.00$) – Some positive changes were generalised in natural situations ($p=0.00$) – An independent health check 4 years after program tended to favour the intervention pupils, requiring less medical treatment for LBP ($p=0.07$)	Programs involving practice and motivating strategies impart health knowledge and habits more efficiently than those restricted to the mere transmission of information There is a pressing need for multidisciplinary interventions aimed at developing healthy habits to promote postural hygiene in childhood
Storr-Paulsen, 2002 [67]	Original study *n*: 532 (intervention: 289, control: 243) Age: 6–15	Body-consciousness program through increased awareness among teachers (information about ergonomics, posture change, advantages of physical activity)	After 1 year of intervention, the intervention had no effect on back pain of pupils	The intervention's ineffectiveness might be explained by the relative short time of implementation and practical problems at the school

Table 2 Overview of studies on risk factors for LBP in schoolchildren, including type of article, relevant specific outcomes and authors' main conclusions

Authors	Type of article Number (*n*) Age (mean and/or range in years)	Specific outcomes	Original authors' main conclusions
Balagué et al., 1995 [4]	Original study (cross-sectional survey) *n*: 615 Age: 14 (range12–17)	Girls reported non-specific LBP more frequently than did boys. Positive-affect scores were associated with significantly reduced lifetime prevalence of non-specific LBP and its consequences, while negative-affect scores were associated with significantly increased lifetime prevalence	Psychological factors play a role in reporting of non-specific LBP in schoolchildren
Balagué et al., 1999 [5]	Non-systematic review	The factors most strongly associated with LBP in schoolchildren are: age, traumatic history, family history, trunk asymmetry, height, female gender, competitive sports, high level of physical activity and psychological factors	A majority of the studies were cross-sectional. There is a lack of agreement among authors. Longitudinal, epidemiological studies are mandatory in order to better comprehend the risk factors of LBP
Burton et al., 1996 [8]	Original study (5-year longitudinal interview-and-questionnaire-based survey) *n*: 216 Age: 11 (at baseline)	No statistically significant relationships were found between flexibility and any of the LBP variables There was a positive link between sports exposure and LBP only for boys, who had a higher exposure than girls to more strenuous sports activities; severity of LBP was not related to sports exposure	Back pain in adolescents is common. It increases with age and is recurrent, but in general does not deteriorate with time. Much of the symptomatology may be considered a normal life experience, probably unrelated to adult disabling trouble
Cardon et al., 2004 [12]	Original study (cross-sectional, using standardised fitness test and questionnaire) *n*: 749 Age: 9.7 (8–12)	In girls the frequency of moderate-intensity physical activity was significantly lower in the pain-reporting pupils. Other physical-activity estimates, physical-fitness scores, BMI and body fat did not differ significantly between children with and without pain report. In girls a more negative attitude regarding the safety of physical activity was associated with pain report	The hypothesis that fitter pupils report less back or neck pain could not be confirmed. A longitudinal study with a follow-up into adolescence is needed to further explore the role that promoting physical fitness and physical activity may have in the prevention of back and neck pain at young age
Duggleby and Kumar, 1997 [15]	Non systematic review	In the literature, associations are found between juvenile LBP and developmental abnormalities, pathology, age, gender, race, growth, biomechanical and anthropometric factors, sports (participation, hours of training), familial relationship and smoking	The literature seemed to indicate two categories of adolescents at risk for LBP: (1) adolescents at the peak of the growth spurt, engaged in competitive sports involving large, sudden flexion/extension/hyperextension movements with rotation, and training in excess of 15 h per week, (2) adolescents just past the growth spurt, who tended to be inactive and possibly smoked
Ebbehoj et al., 2002 [16]	Narrative review	The literature points out some important possible risk factors for LBP: minimal physical activity, intensive sports, genetics, psychosocial factors, smoking and leisure-time activities with a high physical impact	The morbidity related to non-specific LBP in adolescents has not been elucidated. Future research deserves a high priority to provide evidence for a relevant prevention strategy
Feldman et al., 1999 [19]	Original study (prospective, repeated-measures cohort design) *n*: 502 (incidence cohort 377) Age: 14	Smokers experienced LBP more than non-smokers did, with a dose-response relationship between amount smoked and development of LBP	Smoking was found to increase LBP risk in adolescents. If young people learn good lifestyle habits early, perhaps the burden of disabling back pain in the population can be lessened

Table 2 (continued)

Authors	Type of article Number (*n*) Age (mean and/or range in years)	Specific outcomes	Original authors' main conclusions
Feldman et al., 2001 [20]	Same as previous study	Factors associated with development of low back pain (over a 6-month period) in adolescents were high growth, poor quadriceps and hamstring flexibility, working during the school year, and smoking	More research – regarding prevention before people enter the workforce – is needed. Modifying risk factors such as smoking and poor leg flexibility might serve to prevent development of LBP in adolescents
Feldman et al., 2002 [21]	Same as previous study	Adolescents who worked were more likely to develop pain, as were those who had a lower mental health score. White-collar jobs were associated with higher risk of LBP than blue-collar jobs	The conclusion that work is associated with musculoskeletal pain development in adolescents implies that implementation of prevention strategies in the workplace should include adolescents who work
Goldberg et al., 2000 [22]	Systematic review	Data for studies in adults are fairly consistent with the notion that smoking is associated with non-specific back pain. However there are few direct data regarding the pathologic origin of back pain in children and adolescents	It is possible that smoking is implicated in the initiation of back pain, or in the exacerbation of pre-existing back pain or both
Goodgold et al., 2002 [23]	Original study (cross-sectional survey) *n*: 345 Age: 11–14	Younger children carried proportionally greater backpack loads (scales were provided for students to weigh themselves with/without backpacks). Percentage of body weight carried was not related to history of back pain	Concerns by parents and professionals that children carry heavy loads are justified; however, the relationship with back pain needs further evaluation
Grimmer and Williams, 2000 [25]	Original study (cross-sectional) *n*: 1,296 Age: 8–12	Gender- and age-specific associations found between recent LBP and time spent sitting, backpack load, time spent carrying backpack, and time playing sport	Concern is warranted regarding adolescent spinal responses to repeated heavy load and prolonged sitting. Parents and teachers should insist on constraints that limit load carrying and lengthy periods of sitting
Gunzburg et al., 1999 [26]	Original study (cross-sectional) *n*: 392 Age: 9	Significant correlation was found between LBP and unhappiness, sleeplessness and perceptions of ill health. There was strong correlation between LBP and perception by children that one or both parents were back-pain sufferers. LBP reports were higher in children reporting video-game playing more than 2 h per day, but this was not true for TV watchers. Schoolbag-carrying method and sports activity were not associated with pain reports. Only one of the 19 clinical parameters was associated with self-reported LBP	There are few clinical signs that can help in detecting schoolchildren with LBP. There was a significant correlation between self-reported LBP and children's general well-being and parental history of LBP
Harreby et al., 1999 [28]	Original study (cross-sectional survey) *n*: 1,389 Age: 13–16	Recurrent/continuous LBP in a moderate-to-severe degree was positively correlated to BMI exceeding 25 kg/m^2, competitive sports for boys, poor physical fitness, daily smoking, heavy jobs in off-school hours and reduced quality of life. Daily smoking and heavy jobs were strongly associated with severe LBP	The importance of the findings seems unclear Causal importance of the associated factors in the development of severe LBP is unknown

Table 2 (continued)

Authors	Type of article Number (*n*) Age (mean and/or range in years)	Specific outcomes	Original authors' main conclusions
Hutchinson, 1999 [30]	Original study consisting of two parts (prospective over 7-week period/retrospective over 10-month period) *n*: 7/11 Age: 15–17	Over a 7-week period, the incidence among seven members of the national rhythmic-gymnastics team was 474 musculoskeletal complaints. Retrospectively, 46 musculoskeletal injuries were reported	Rhythmic gymnasts are at relative increased risk of suffering low back complaints secondary to their sport. They should be included in the sports at risk of low back injury. Further study is necessary to assess whether interventions will reduce the incidence of low back complaints in this sport
Iyer, 2001 [31]	Original study (cross-sectional survey) *n*: 248 (India) and 103 (USA) Age: 9–20.6	50% reported shoulder/back pain attributed to school items carried. Pain reports were not correlated with BMI, % of body weight carried, or mood. Americans were more stressed, sad and overweight than Indians.	Pain due to carried school items is a significant problem that school districts need to address
Jones et al., 2003 [33]	Original, prospective cohort study with1-year follow-up *n*: 1,046 Age: 11–14 (at baseline)	There was no link between mechanical load (schoolbag weight) and short-term risk of new onset LBP. Adverse psychosocial factors and other, somatic, complaints were predictive for future LBP	The adult back-pain "career" may begin at least as early as adolescence. As with adults, psychosocial factors are associated with an increased risk of developing LBP in schoolchildren
Korovessis et al. [36]	Original study (cross-sectional) *n*: 3,441 Age: 9–15	BMI did not correlate with LBP. Sports exposure seemed to increase LBP in girls. Short children who carry backpacks as heavy as those carried by tall children of the same age were more prone to LBP. The way of carrying a backpack (one or two straps) was not correlated with LBP	Girls aged 11–12 years should carry light backpacks and avoid strenuous sports to decrease the probability of experiencing dorsal pain. Shorter children should not carry backpacks that are as heavy as those carried by tall children of the same age. Parents should not worry about the way their child caries his/her backpack
Kovacs et al., 2003 [37]	Original study (cross-sectional survey) *n*: 7,361 (and 13,553 parents) Age: 13–15	LBP was significantly associated with reporting difference in leg length, practice of any sport more than twice a week No association was found between LBP and BMI, the manner in which books were transported, hours of leisure sitting, alcohol intake or cigarette smoking	Adolescents have prevalence similar to that of adults. LBP is strongly associated with pain in bed or upon rising, and mildly with practicing sports more than twice a week. Additional longitudinal studies are needed to establish which of these factors increase the risk for LBP in adolescents
Kristjandottir and Rhee, 2002 [39]	Original study (cross-sectional survey) *n*: 2,173 Age: 11–12 and 15–16	Age, morning tiredness, eating habits and parental support emerged as major factors associated with back pain in schoolchildren	Study results highlight the importance of acquiring and practicing a healthy lifestyle for the benefit of prevention and/or diminution of the burden of current and future back pain
Kujala et al., 1996 [40]	Original study (3-year follow-up) *n*: 98 Age:10–13 (at baseline)	Severe LBP problems occurred only during the growth spurt of adolescence Back pain was more reported in athletes (*n*: 29) than in non-athletes (*n*: 6)	Excessive loading that involves a risk for acute low back injuries during the growth spurt is harmful to the lower back
Kujala et al., 1999 [41]	Original study (cross-sectional survey) *n*: 698 Age: 10–17	Low back pain, upper limb pain and lower limb pain were found more often in subjects participating in large amounts of leisure physical activity, while non-musculoskeletal pains (in particular, headache) among boys tended to be less common. Co-occurrence of different musculoskeletal pains was common in subjects participating in sports	In addition to its likely long-term benefits, vigorous physical activity causes musculoskeletal pains during adolescence. This should be considered when tailoring health-promotion programs to adolescents

Table 2 (continued)

Authors	Type of article Number (*n*) Age (mean and/or range in years)	Specific outcomes	Original authors' main conclusions
Lebskowski, 1997 [43]	Original study *n*: 2,346 (and 970 high-school students) Age: 17±1	In pupils a correlation between LBP and incorrect sitting position and smoking was found	Incorrect sitting and smoking increase the risk for back pain in pupils
Lee et al., 1999 [45]	Original (5-year prospective) study *n*:67 Age: 17 ±2	Testing isokinetic trunk performance at 60°/s revealed that the extension/flexion ratio was a more sensitive parameter than the peak-torque or the left rotation/ right rotation ratio in predicting LBP episodes	Imbalance of trunk muscle strength, i.e., lower extensor muscle strength than flexor muscle strength, might be one risk factor for LBP incidence
Mackenzie et al., 2003 [46]	Non-systematic review	Data on the association between backpack variables, posture and juvenile LBP are inconsistent Backpacks have been evaluated by consumer reports, but there are no studies showing effectiveness in reducing back complaints	No studies can be found to substantiate an association between use of backpacks and onset of structural spinal deformities. A longitudinal study is needed to determine whether regular book-bag use is a risk factor for developing back pain and to identify whether a critical book-bag weight exists
McMeeken et al., 2001 [47]	Original study (cross-sectional survey) *n*: 614 Age: 9–27	Greater incidence and magnitude (VAS) of back pain among gymnasts and dancers, compared to controls. For dancers risk increased when weekly activity exceeded 30 h	Dancers appear to increase their risk of developing back pain when weekly activity exceeds 30 h. Back pain in active and inactive adolescents presents a significant challenge for health-care practitioners
Merati et al., 2001 [49]	Original study (experiment and retrospective survey) *n*: 35 Age: 11.3	Cardiovascular effort (tested by VO_2 max, pulmonary ventilation, and heart rate with/without backpack) required for locomotion while carrying backpack was minimal. Fatigability and back pain were more likely to occur in less physically fit subjects	Improving the physical fitness of schoolchildren appears to be a way to prevent occurrence of back pain during locomotion with a school backpack
Negrini and Carabalona, 2002 [50]	Original study (cross-sectional) **A** *n*: 237; age: 11.3 **B** subgroup *n*:115; age: 11.7	**A** Children's backpack load exceeded the legal limits set for adults. The school system, parents and children played a role in the weight carried (recorded for 6 days) **B** The association between pain and backpacks was indirect, i.e., there was correlation with subjective fatigue and time spent carrying but not with the actual weight	Daily backpack carrying is a frequent cause of discomfort in schoolchildren. The relationship between load and back pain is indirect, suggesting that physical and psychological factors need to be investigated. Reduction of daily backpack load is recommended
Newcomer and Sinaki, 1996 [51]	Original study (4-year follow-up) *n*: 96 Age: 10–19 (at follow-up)	Increased physical activity was significantly associated with a history of LBP (evaluated with a 5-question questionnaire). Increased isometric back flexor strength was significantly associated with a history of low back pain and LBP in previous year. Rate of change in back flexor strength over 4 years had a significantly positive association with LBP occurrence in previous year	LBP is more common in children with increased physical activity and stronger back flexors The main causes of LBP in children are musculotendinous strains and ligamentous sprains

Table 2 (continued)

Authors	Type of article Number (*n*) Age (mean and/or range in years)	Specific outcomes	Original authors' main conclusions
Ogon et al., 2001 [52]	Original, prospective cohort study with 2-year follow-up *n*: 120 Age: 17 (14–20) (at baseline)	Radiological images (at baseline) in elite skiers showed lumbar radiographs to be of limited value for predicting LBP, except for severe anterior end-plate lesions	Adolescent students playing elite sports with severe, lumbar anterior end-plate lesions have an increased risk of developing LBP under high performance training
Rozenberg and Bourgeois, 1999 [56]	Non-systematic review	Book-bag weight, smoking and participation in competitive sports were associated with back pain at young age	Risk of LBP in children is multifactorial. High prevalence numbers do not justify medicalising LBP in schoolchildren
Salminen et al., 1995 [58]	Original, prospective 3-year follow-up study *n*: 1,377 (follow-up: *n*: 62) Age: 15 (at baseline)	At baseline and at follow-up, subjects with initial LBP (*N*: 107) were characterised by low frequency of physical activity, decreased spinal function and strength. Disc degeneration and disc protrusion at baseline predicted future frequent LBP	In several subjects, after the period of rapid physical growth, there seemed to be a causal relationship between early evolution of the degenerative processes of the lower lumbar discs and frequent LBP
Salminen et al., 1999 [59]	Original, prospective 9-year follow-up study *n*: 1,503 (follow-up questionnaire: *n*: 70) Age: 14 (at baseline)	Risk of persistent, recurring LBP was highest in individuals showing early signs of disc degeneration	Individuals with disc degeneration soon after the phase of rapid physical growth have not only an increased risk of recurrent LBP at this age, but also a long-term risk of recurrent pain up to early adulthood
Sheir-Neiss et al., 2003 [61]	Original, cross-sectional study *n*: 1126 Age: 12–18	Self-reported back pain (month's prevalence of back and neck pain) was associated with poorer general health, more limited physical functioning, more bodily pain and larger BMI. As compared with no or low use of backpacks at school, heavy use was independently associated with back pain. Adolescents with back pain carried heavier backpacks (weight on 1 day) that represented a greater percentage of their body weight	Adolescents with back pain are more likely to be female, have a higher BMI, report poorer health, spend more time watching TV, have a heavier backpack and carry a backpack more frequently Efforts to minimize adolescents' backpack use are recommended
Sjölie, 2002 [63]	Original study (cross-sectional survey) *n*: 105 Age: 14.7 (14–16)	A non-significant tendency towards an association between poor well-being and LBP. Association was strongest for self-reported fitness, significant for cheerfulness, but not for the calmness item. LBP was not associated with either parental pain or social class	Poor well-being, in particular poor self-perceived fitness, is associated with LBP. No associations are found between social class, parental LBP and juvenile LBP
Sjölie and Ljunggren, 2001 [64]	Original study (cross-sectional and prospective parts, with 3 year follow-up) *n*: 88 Age: 14.7 (14–16)	Low lumbar extension strength and high ratios between lumbar sagittal mobility and lumbar extension strength were associated with LBP (cross-sectional part) and predicted future LBP (prospective part)	Insufficient strength and stability in the low back are important factors for both current and future back pain in adolescents
Staes et al., 2003 [66]	Original study (cross-sectional survey) *n*: 620 Age: 17	A higher degree of somatising, diminished self-esteem and augmented negative affect were related to self-reported LBP	Some adolescents might have traits that make them prone to become low back sufferers. Psychosocial factors should be taken into account when investigating LBP in adolescents

Table 2 (continued)

Authors	Type of article Number (*n*) Age (mean and/or range in years)	Specific outcomes	Original authors' main conclusions
Storr-Paulsen, 2002 [67]	Original, prospective intervention study with 1 year follow up *n*: 686 (and 972 parents)	Baseline values showed a correlation between age and back pain and dislike of school. Physically active pupils liked going to school more. Back pain correlated with parental pain	Psychosocial factors such as dislike of going to school may be risk factors for back pain in schoolchildren
Szpalski et al., 2002 [68]	Original, 2-year prospective longitudinal study *n*: 287 Age: 9–12	Using a questionnaire and medical examination, it was found that the quality of falling asleep, happiness, heavy satchel, and painful lumbar muscles distinguished "never" having LBP from "always" having LBP. Health perception and weight were associated with "incident" LBP	Among the few significant variables, those related to general well-being and self-perception of health are prominent. It appears that psychological factors play a role in the experience of LBP, in a similar way to what has been reported in adults
van Gent et al., 2003 [70]	Original, cross-sectional study *n*: 745 Age: 12–14	No association found between perceived and real weight of the bag (weight on 1 day). The (relative) weight of schoolbags was not related to complaints of neck and/or shoulder and back Scores on psychosomatic questions were higher for children with complaints on neck, shoulder, back	Psychosomatic factors appear more strongly related to the occurrence of neck and/or shoulder and back complaints than are type and weight of schoolbag and other physical factors
Viry et al., 1999 [72]	Original study (cross-sectional survey) *n*: 123 Age: 14	A relative schoolbag weight of 20% or more (schoolbag weight on day of survey) was associated with history of back pain. Sitting on chair's edge while completing the questionnaire was significantly associated with history of a physician visit for back pain	A longitudinal prospective study is needed with the goal of devising preventive strategies to reduce risk of LBP in adulthood
Watson et al., 2003 [73]	Original, cross-sectional study *n*: 1,446 Age: 11–14	Schoolbag weight (5-day bag weight diary used) and physical activity were not associated with self-reported LBP. Strong associations observed for emotional problems, conduct problems, troublesome headaches, abdominal pain, sore throats and daytime tiredness	Psychosocial rather than mechanical factors are more important in LBP occurrence in young populations and might reflect distress in schoolchildren
Wedderkopp et al., 2003 [74]	Original study (cross-sectional survey) *n*: 481, Age: 8–10 *n*: 325, Age: 14–16	No association was found between objectively measured level of physical activity (using accelerometers) and back pain in children and adolescents	When level of physical activity is measured objectively, there is no association with self-reported back pain in children and adolescents. A method should be used to compare different types of activities to discern the possible noxious and beneficial effects of physical activity
Widhe, 2001 [75]	Original, longitudinal study with 10-year follow-up *n*: 90 Age: 5–6 (at baseline)	Kyphosis and lumbar lordosis increased by 6° each, while total sagittal mobility of the spine decreased. Posture, mobility, standing or sitting height, or body weight, either at ages 5–6 years or 15–16 years seemed to have no significant relationship to likelihood of LBP at age 15–16	LBP is not related to posture, spinal mobility or physical activity

program was associated with increased self-reported LBP but with significantly decreased utilization of medical care. The study's shortcomings included the non-randomised design and the fact that the population of schoolchildren at the beginning and end of the study was partially different. Therefore, results cannot be generalised.

Cardon et al. [13] evaluated the effects of a 6 h back-education program, implemented by a physical therapist in 347 schoolchildren aged 9 to 11 years. A controlled pre-post design with a 1-year follow-up was used. The program resulted in better use of back-care principles and in decreased self-reported back- and neck-pain prevalence. However, the quasi-experimental design requires cautious interpretation of the study results. A third intervention study was performed by Mendez et al. [49], evaluating a postural-hygiene program. It consisted of 11 sessions: three devoted to physiotherapy exercises and eight to behaviour intervention. As in the study by Cardon et al. [13], a quasi-experimental design was used with a 12-month follow-up assessment. The postural-hygiene program was applied to 106 schoolchildren aged 9 years. The intervention group showed increased back-related knowledge and improved general postural habits. In addition, making use of a placebo group, it was shown that programs involving practice and motivating strategies impart health knowledge and habits more efficiently than those restricted to the mere transmission of information. In an independent health check conducted by the local school-health services 4 years after completion of the postural hygiene program, the intervention group required less medical treatment for LBP (p=0.07), reflecting a slight trend of LBP prevention among participants. However, the value of the follow-up evaluation can be questioned.

In the study by Feingold and Jacobs [19], evaluating an educational intervention focusing on backpack-wearing posture, it was concluded that postures had not significantly improved after the intervention, while a decrease of pain was reported. However, the experimental group consisted of only nine children, and a decrease in back pain was reported by only two participants. As a result, findings cannot be generalized. In contrast to the above-mentioned studies, the educational intervention evaluated by Storr-Paulsen [68] did not have any effect on the back pain of pupils. The intervention, evaluated in approximately 250 children, was developed to increase body consciousness and consisted of information on ergonomics, change of posture and the advantages of physical activity by teachers. According to the authors, the lack of effect might be explained by the relatively short time of implementation and unexpected practical problems at the school where the intervention was implemented.

While it can be concluded that the majority of the results of the intervention studies are promising, there is no evidence that LBP in schoolchildren can be prevented by an educational intervention program. Moreover, the large differences between the evaluated programs make comparison and the formulation of guidelines difficult, and it needs to be taken into account that the reviewed studies have several limitations.

Studies on risk factors

The following modifiable risk factors were evaluated in the literature: body mass index (BMI), mobility and flexibility of muscles and joints, muscular strength, sports participation, physical activity and physical fitness, backpack-related factors, sitting posture and sedentary activity, working, psychosocial factors, smoking and other factors.

Body mass index

In line with a previous review paper [5] that included studies published since 1992, the present literature-update search shows that an association between LBP and BMI is still unproved. In a cross-sectional study in 13-to-16-year-old Danish schoolchildren by Harreby et al. [29], recurrent or continuous LBP in a moderate-to-severe degree was positively correlated to BMI more than 25 kg/m^2. Along the same lines, Sheir-Neiss et al. [62] reported larger BMI values in adolescents with back pain. On the other hand, the cross-sectional studies of Kovacs et al. [38] in 7,361 adolescents, of Watson et al. [75] in 1,446 adolescents, of Cardon et al. [14] in 749 children, of Korovessis et al. [37] in 3,441 children, and the Iyer study [32] in 36 children aged 11 to 14 years reported no association between BMI and LBP. However, in the latter study, results are not clearly reported. Also, considering that the study is performed by a 14-year-old, the value can be questioned. The most carefully designed study on the association between LBP and BMI is the prospective population-based cohort study by Jones et al. [34] in 1,046 schoolchildren. It reports that neither BMI nor its change over the follow-up year was associated with an increase in the risk of future LBP. The influence of BMI on LBP at school age is still unclear, as is the possible influence of obesity during childhood or adolescence on adult LBP. According to Lake et al. [43], obesity in early adulthood increases the risk of back-pain onset among women, whereas BMI at age 7 has no relationship with the onset of pain in either sex.

Mobility and flexibility of muscles and joints

According to the review by Balagué et al. [5], LBP seems to be correlated with tightness of the posterior thigh muscles, while the correlation with the sagittal mobility of the lumbar spine remains debatable. In line with these findings, Feldman et al. [21] found that tight hamstrings and tight quadriceps femoris are associated with the development of LBP. However, as reported by the authors, the study has considerable limitations, such as the loss of 308 of the original 810 subjects. In contrast to the findings of Balagué et al. [5] and Feldman et al. [21], a cross-sectional study in a cohort of 1,389 schoolchildren by

Harreby et al. [29] found no significant correlation between LBP and tightness of the hamstring muscles, even in cases of tightness beyond 40°. Furthermore, the correlation between hypermobility and LBP could not be confirmed in the study by Harreby et al. [29] and in the longitudinal studies of Widhe [76] and Burton et al. [9]. These reported, respectively, that spinal mobility and lumbar sagittal flexibility were not associated with LBP variables. Similarly, Feldman et al. [21] did not find an association between lumbar flexion and the development of LBP. On the other hand, Salminen et al. [60] found that decreased spinal mobility is associated with LBP in adolescents. Since findings in the literature are contradictory, it can be concluded that more studies are necessary to clarify the relationships between LBP and mobility and flexibility in schoolchildren, and that LBP-prevention guidelines focusing on modification of mobility and flexibility are not evidence-based.

Muscular strength

In line with a previous review [5], the present literature search shows that LBP in schoolchildren cannot simply be attributed to muscle weakness. According to Feldman et al. [21], poor isometric strength of the abdominal muscles is not a risk factor for the development of LBP in adolescents. However, as mentioned above, the study has considerable limitations. In contrast to the findings of Feldman et al. [21], Newcomer and Sinaki [52] found in a longitudinal study that increased trunk flexor strength was positively associated with LBP in adolescents, whereas in the 5-year prospective study by Lee et al. [46] lower extensor-muscle strength than flexor-muscle strength was found to be a risk factor for LBP incidence in 67 subjects aged 17 years. However, in the latter study isokinetic testing was used, which can be questioned as a physiological muscle activity. Additionally, Sjölie and Ljunggren [65] found that insufficient strength and stability in the low back are important for both current and future back pain. In line with these findings Salminen et al. [59] reported, in a study with a strong longitudinal design with 3-year follow-up, that decreased spinal strength increased the risk for back pain in schoolchildren. However, it can be concluded that there is no evidence that muscle strengthening has a preventive effect on LBP in schoolchildren.

Sports participation, physical activity and physical fitness

In the narrative reviews of Ebbehoj et al. [17] and Duggleby and Kumar [16], it is concluded that inactivity and intensive sports exposure are both important risk factors for LBP in schoolchildren. Along the same lines, according to the review of Balagué et al. [5], competitive sports activities and a high level of physical activity are associated with an increased risk of LBP, particularly among young athletes. The risk depends on the type of sport, the level of competition, the intensity of physical training and acute spinal trauma [5]. Ogon et al. [53] reported an increased risk of LBP in adolescents who participate in elite sports under high-performance training. However, in the latter study only skiers were included, and, as a result, findings cannot be generalized. Similarly, the findings of Hutchinson [31], reporting that rhythmic gymnasts are at relative increased risk of suffering LBP due to their sport, cannot be generalized. Moreover, in the study by Hutchinson [31], only 11 subjects were included. Also, the findings of Kujala et al. [41] – that reports of LBP lasting more than 1 week were higher among adolescent athletes than among adolescent non-athletes – were based on pain reports of a small sample of six subjects. As a result, the findings cannot be generalized. Another study focusing on the influence of demanding physical activity, such as that imposed by dance or gymnastics, is the report by McMeeken et al. [48]. This found that, in dancers, no association existed between LBP and average total hours of activity, until this exceeded 30 h per week.

Besides the studies pointing out the risk for LBP in young athletes, several studies evaluated the risk of physical activity and sports in non-athlete populations. Kovacs et al. [38] found in 7,361 subjects aged 13–15 years that cumulative LBP was associated with practicing any sport more than twice a week. In the recent cross-sectional study by Korovessis et al. [37], the association between sports exposure and LBP was only significant in girls. On the other hand, the cross-sectional survey by Harreby et al. [29] and the 5-year longitudinal study by Burton et al. [9] found a positive link between sports participation and back pain only for boys, while severity was not related to sport. Also, Kujala et al. [42] found a positive association between LBP and a high level of leisure physical activity. Similarly, the study by Newcomer and Sinaki [52] reported that LBP was more common in children with increased physical activity; and the recent prospective study by Jones et al. [34] showed an increased risk for LBP in those undertaking a high level of physical exercise. On the other hand, in a sample of 2,173 schoolchildren, Kristjandottir and Rhee [40] reported a negative correlation between back pain and sports participation or between back pain and physical activity. Along the same lines, the survey-based longitudinal study by Salminen et al. [60] pointed to low leisure-time physical activity as a risk factor, and Szpalski et al. [69] reported a higher incidence of LBP in 9–12-year-old children who did not walk to school as compared with children who did walk to school, while sports participation had no significant influence. Moreover, according to findings by Cardon et al. [14], Feldman et al. [21], Iyer [32], Watson et al. [74], Wedderkopp et al. [75] and Widhe [76], total amount of physical activity was not associated with back-pain reports in schoolchildren.

The study by Wedderkopp et al. [75] is the first making use of objectively measured physical activity in relation to back pain. It can be concluded that in children and adolescents there are indications that high-performance training in certain sports increases the risk for back pain, but the relationship between physical activity and back pain has inconsistencies. Methodological shortcomings, such as the lack of definitions, the difficulty in measuring physical activity in children [36], the inconsistent classification of physical activity and a primary reliance on self-reported sports history, are the biggest difficulties in drawing evidence-based conclusions regarding the link between physical activity and back pain at young age.

The association between back pain and physical fitness has also been studied in the literature. According to a recent study [14] making use of a standardised fitness test, there is no correlation between back pain and fitness parameters in children aged 9–11 years. On the other hand, Kristjandottir and Rhee [40] and Sjölie [64] reported that poor physical fitness increased the risk for back pain in schoolchildren. However, in the two latter studies the fitness level was self-reported and as a result the validity can be questioned. It can be concluded that there is no evidence that being more physically fit has a preventive effect on LBP in schoolchildren.

Backpack-related factors

In line with the recent review by Mackenzie et al. [47], conflicting study results are found for the association between backpack-related factors and LBP in schoolchildren. Various studies have reported no association between backpack-related factors and back pain at young age. In one of the most carefully designed surveys, including 1,446 children, Watson et al. [74] recently demonstrated the lack of significant association between LBP and either the type of school bag, the method of carrying or the percentage of body weight carried. Actually, the lowest risk of reporting LBP was found among those carrying the highest percentage of body weight. Along the same lines, van Gent et al. [71] found that children with bags weighing more than 18% of their own body weight reported back complaints less frequently than children who carried lighter bags. Another recent survey by Goodgold et al. [24] including 345 children showed no direct relationship between back pain and backpack use, and Grimmer and Williams [26] reported that the manner of backpack carrying was not associated with LBP. Similarly, Korovessis et al. [37] recently found in a large sample of schoolchildren that backpack-weight percentage and method of carrying were not associated with LBP.

On the other hand, at least two studies have described an association between reported perceived load and LBP [51, 69]. In the carefully designed study by Negrini and Carabolona [51] the variable associated with LBP was "fatigue during backpack carrying", while the average backpack weight/body weight ratio, the maximum backpack weight/body weight ratio and "feeling the backpack too heavy" were not directly associated with LBP. Moreover, the study showed large differences not only in terms of the backpack weights among the various schools tested, but also among the days of the week and among the pupils in the same class. Along the same lines, in the study by Szpalski et al. [69], children who responded affirmatively to the question, "Do you find your satchel too heavy?" were more prone to report ongoing back pain. The association between LBP and items carried was also pointed out by Iyer [32]. However, as stated above, the quality of the latter study can be questioned. In the recent study by Shier-Neiss et al. [62], carrying a sports bag in addition to a backpack was not associated with back pain. Also, Kovacs et al. [38] reported no significant association between LBP and the manner in which books were carried by 13–15-year-olds. Along the same lines, the study by Jones et al. [34] showed little evidence of an increase in short-term risk for LBP associated with mechanical load across the range of weights commonly carried to school by children. In the study by Viry et al. [73] it was reported that 50% of the children carrying their schoolbags in one hand had missed school or sports due to back pain, while in the children carrying their backpacks over both shoulders this incidence was only 11.5%. However, since only 22 children carried their backpacks in one hand, the conclusion was based on only 11 children reporting school or sports absence due to back pain. A major problem is that, at best, many studies looked only once at the actual weight of backpacks, while Negrini and Carabalona [51] showed large variations among the days of the week within the same class of the same school. Furthermore, Merati et al. [50] reported that the cardiovascular effort required for locomotion carrying a backpack is minimal. It can be concluded that attributing a major role to backpacks alone seems a shortcut difficult to support. Although it is recognised that there is a widespread interest in "heavy" school bags as a risk factor for LBP, there is little persuasive scientific evidence for a causative relationship. Thus, it might follow that interventions to reduce school-bag weight are not likely to be particularly effective to prevent LBP in schoolchildren [10].

Sitting posture and sedentary activity

According to a previous review [5], sitting was found to be the most common factor associated with back pain. Along the same lines, Sheir-Neiss et al. [62] reported that adolescents with back pain spent significantly more hours watching TV than those without back pain did, and Grimmer et al. [26] found gender- and age-specific associations between the amount of time spent sitting and recent LBP. As a result, it was suggested by Grimmer et al. [26] that parents and teachers should insist on constraints that limit lengthy periods of sitting. However, in the studies by Kovacs et al. [38] and Watson et al. [74] the association between LBP and hours of leisure sitting was not significant. Along the same lines, Jones et al. [34] prospectively demonstrated that prior sedentary activity cannot be considered a short-term risk factor for future LBP. On the other hand, in the cross-sectional study by Gunzburg et al. [27] in 9-year-old children, back-pain reports were higher in children who played video games for more than 2 h per day, whereas this was not the case for children who watched television for more than 2 h per day. According to the authors, differences between the postures may possibly explain the differences in pain reports. Similarly, the cross-sectional study by Lebkowski [44] of 2,346 subjects aged 17 years reported a correlation between LBP and incorrect sedentary position. Viry et al. [73] found that sitting on the edge of the chair while completing a questionnaire was significantly associated with a history of a physician visit for back pain. Further study is necessary to explore whether certain prolonged sitting postures or sedentary activities are risk factors for developing LBP. It can be concluded that the association between LBP and sitting in schoolchildren remains unclear. Furthermore, it proved impossible to locate a study evaluating whether the loading on young, growing body structures – associated with poor, prolonged sitting postures and a sedentary state – has an impact later in life.

Working

Feldman et al. [22] found that working during off-school hours increased the risk of LBP in schoolchildren. Moreover, white-collar jobs were associated with higher risk of LBP than blue-collar jobs. In line with the findings of Feldman et al. [22], Harreby et al. [29] found a positive association between heavy jobs during off-school hours and LBP. Also, in the cross-sectional survey-based study by Watson et al. [74] children with part-time jobs had a 60% higher chance of reporting LBP, although among those with part-time jobs there was no association with reports of lifting heavy items. Along the same lines, having a part-time job significantly increased the risk for LBP in the recent prospective study of Jones et al. [34]. It can be concluded that working during off-school hours is associated with reported LBP in schoolchildren. However, there is no evidence that modification of working during off-school hours has a preventive effect on LBP in schoolchildren. Moreover, it needs to be taken into account that muscle fatigue from working may have influenced pain reports.

Psychosocial factors

According to a prior study [3], psychological factors, labelled "positive" were associated with a reduction of lumbar pain, whilst those factors considered "negative" were accompanied by an increase of this sort of pain. These findings are in agreement with other studies in the literature, resulting in the conclusion of a previous review paper [5] that depression and emotional factors have been found to be significantly associated with LBP. Along the same lines, the review by Ebbehoj et al. [17] points out that psychosocial factors are important risk factors for LBP. Moreover, in a recent study by Watson et al. [74] it was suggested that psychosocial factors are more important than mechanical factors in LBP occurring in young populations. Similarly, Szpalski et al. [69] found that lower scores for happiness, sleep quality and health perception were associated with higher back-pain reports in 9–12-year-olds, and it was concluded that psychological factors may play a role in the experience of back pain in children in a similar way to what has been reported in adults. Moreover, Gunzburg et al. [27] found in 9-year-olds that general well-being was correlated with back pain.

In line with these findings, numerous recent studies in schoolchildren have reported an association between back pain and psychological factors, such as morning tiredness and parental support [40], poor well-being, and, in particular, poor self-perceived fitness [64], a higher degree of somatising, diminished self-esteem and augmented negative affect [67], dislike of going to school [68], psychosomatic factors [71], life quality [29] and poor mental health [21]. Furthermore, according to the prospective study by Jones et al., [34] high levels of adverse psychosocial exposure, presence of behaviour problems such as anger, disobedience and violence, and high levels of hyperactivity were associated with an increased risk of developing LBP in adolescents.

It can be concluded that there is moderate evidence that psychosocial factors are significantly related to back-pain reports in schoolchildren. However, there is no evidence that modification of psychological factors may have a preventive effect on LBP in schoolchildren. Moreover, it can be questioned to what degree psychological factors can be modified.

Smoking

According to the systematic review by Goldberg et al. [23], data of studies in adults are fairly consistent as to the idea that smoking is associated with non-specific back pain. However, little direct data exists regarding the pathologic origin of back pain in children and adolescents. In the non-systematic reviews of Balagué et al. [5], Rozenberg and Bourgeois [57], Duggleby and Kumar [16] and Ebbehoj et al. [17], it was concluded that smoking was significantly associated with back pain in youngsters. Along the same lines, the association between back pain and smoking among schoolchildren was confirmed in the literature by Feldman et al. [20], Harreby et al. [29], Lebkowski [44] and Kristjandottir and Rhee [40]. By contrast, Kovacs et al. [38] found no association between LBP and cigarette smoking. According to Harreby et al. [29], smoking habits in schoolchildren may indirectly reflect psychosocial and social problems as the main causes in developing LBP. Similarly, Feldman et al. [20] found lower mental-health scores in smokers, compared with non-smokers. It can be concluded that there is no evidence that anti-smoking campaigns will have a preventive effect in LBP. However, as more adverse reactions to smoking are discovered and publicized, it is hoped that the appeal of smoking will be diminished in young people.

Other factors

Finally, some other modifiable factors have been studied in relation to back pain reports in schoolchildren. Kristjandottir and Rhee [40] identified a strong positive relationship between back pain and eating habits, namely, irregular meals, fast food, snacking and coffee drinking. However, besides the cross-sectional design, the latter study is limited in that the many associated factors accounted for less than 10% of total variance of back pain in the sample, suggesting the existence of other potential, yet unmeasured, factors contributing to the incidence of pain. Furthermore, the recent cross-sectional study by Kovacs et al. [38] found no association between LBP and alcohol intake, in a large sample of schoolchildren. However, as reported by the authors, the risk of underreporting of alcohol intake cannot completely be ruled out.

Conclusions

While epidemiology and risk factors of back pain at young age have extensively been described, studies evaluating the effects of interventions to prevent LBP or the consequences of LBP in schoolchildren are still sparse. As a result, the aim of formulating evidence-based guidelines for LBP prevention in schoolchildren could not be accomplished. However, the conclusions of the present literature search may give guidance for further development and evaluation of preventive interventions in schoolchildren.

Primary prevention programs have been part of the school curriculum for years in areas such as dental hygiene, cardiovascular disease and teen pregnancy. The advantages of health education in elementary school systems are the possibility of giving prolonged feedback and the large percentage of the population that can be reached. According to Johnson [33], schools hold enormous potential for helping students develop the knowledge and skill they need to be healthy. Along the same lines, it was shown in the literature that educational interventions designed to prevent LBP resulted in improved back-care-related knowledge or skills [12, 13, 49]. Additionally, four of the five evaluated interventions found a positive effect on back pain or on the consequences of back pain, such as medical consumption [4, 49], in schoolchildren. While it can be concluded that the results of the intervention studies are promising, differences among the interventions, the lack of the evaluation of long-term effects and the limitations of the studies dictate a cautious interpretation and do not allow the formulation of evidence-based guidelines for LBP prevention in schoolchildren. Moreover, there is currently insufficient information to be able to specify what may be the most effective components of interventions.

In order to provide evidence for relevant prevention strategies, intervention studies deserve priority. In addition, evaluating the modifiable risk factors of the incidence of back pain and of the consequences of back pain in schoolchildren is important for the development of preventive interventions. However, many studies carried out to investigate risk factors have the major disadvantage of being cross-sectional. For this reason it is not always possible to distinguish etiologic from prognostic factors. Moreover, according to the present literature review, the role of most factors still remains controversial, namely, BMI; mobility and flexibility; muscular strength; physical activity; physical fitness and sports participation; backpack-related factors; sitting posture and sedentary activity; and smoking. As a result, there is no evidence that modifying these factors will have a preventive effect on LBP pain in schoolchildren. On the other hand, the present literature review gives moderate evidence that psychosocial factors are associated with reports of back pain and related consequences in schoolchildren. Furthermore, according to Power et al. [55], poor emotional adjustment between the ages of 7 and 16 years was significantly associated with LBP at age 33 years. However, it can be questioned whether psychosocial risk factors are modifiable in schoolchildren, and more study is necessary to differentiate between the various psychosocial risk factors. Also, for work during off-school time the findings in the literature are consistent. However, the limited number of studies and the possible confounding effect of muscle fatigue do not justify including this factor in prevention guidance.

Since we can conclude from the literature that back-pain reports in schoolchildren are mainly associated with psychosocial factors, and since it is shown in the literature that LBP in the young is mostly benign and self-limiting [9, 61], it can be argued that there is limited scope for LBP prevention in schoolchildren. Furthermore, an aggregation of symptoms retrieved by questioning children can be misleading and the definition of boundaries between pain as an experience as opposed to pain as a sign of "a medically significant" disease is sometimes difficult. Children are in a general learning process, including for the expression of pain in an adequate and acceptable fashion, both socially and culturally. Therefore, it may be time to look at what the terms pain, aches, disability and disease mean to schoolchildren themselves, and not to simply apply adult definitions to assess children and LBP [6].

While the scope of LBP prevention in schoolchildren is limited, further study is necessary to evaluate whether improving back-care knowledge and postural habits at a young age have a preventive effect on LBP in adults. If young people learn good lifestyle habits early, then perhaps the burden of LBP can be lessened. Therefore, in the future it seems necessary to learn from adult risk factors and to evaluate to what degree the risk of adult LBP can be altered by early interventions. Further study with a follow-up into adulthood is also needed to evaluate whether or not the physical cumulative load experience on the lumbar spine during adolescence contributes to the adult cumulative lifetime load.

Nevertheless, while it can be argued that the need for long-term studies is pressing, the multifactorial character of back pain in adults may make it unrealistic to show a possible preventive effect of early interventions or risk-factor modification in childhood. As a result, it may be necessary to rely on the positive effects on adult risk factors.

While it can be concluded that there are several arguments to justify back education in schoolchildren, Burton et al. [8] argued that the risk exists that early back education results in increased fear-avoidance beliefs about physical activity and reinforces an erroneous belief that there is something seriously amiss. However, in a study by Cardon et al. [12] it was found that pupils who followed back education did not have higher fear-avoidance beliefs than did controls. Furthermore, misconceptions about back pain, which are shown to be widespread in adults and play a role in the development of long-term disability [25], may be prevented by carefully selected and presented health-promotion programs in children, with the merit of demedicalising LBP. For the development of these programs, it is necessary to learn from studies evaluating the implementation of back education through the school system [4, 11,12, 14, 15, 50] and from positive experiences reported in other fields.

It can be concluded that medicalising back pain in schoolchildren needs to be avoided [6, 8, 9]. Longitudinal studies evaluating the possible positive effects of preventive programs and risk-factor modifications at young age are advocated.

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