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REVIEW ARTICLE

Physical activity and low back pain in children and adolescents: a systematic review

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Abstract

Introduction Due to a high prevalence of low back pain (LBP) among children and adolescents, it is significant to seek effective prevention and therapeutic procedures. One idea for the programmes is a potential relation between the occurrence of LBP and the level of physical activity. The aim of this review was to analyse the current knowledge regarding the association between physical activity and LBP among children and adolescents.

Methods Publications were retrieved by searching the following databases: PubMed, The Cochrane library, Web of Science, Medline and SportDiscus with Full Text (EBSCO). The search strategy included keywords related to physical activity and LBP. The studies included were assessed for methodological quality. PRISMA guidelines were followed for the systematic review.

Results The total sample size of the nine included studies consisted of 75,233 subjects, with an age range of 9–19 years. All the studies were assessed to be of high quality. One cohort study and five cross-sectional studies found the association between physical activity and LBP in children and adolescents. The remaining studies found no relationship between physical activity and LBP. These findings showed that both extremes of activity levels (i.e. being very low and very high physically active) are associated with LBP.

Conclusion There is moderate evidence for the association between physical activity and LBP in children and adolescents. The results highlight the need for continued research. It seems that for clear evaluation of the analysed association the prospective cohort studies should be conducted.

Keywords Low back pain · Physical activity · Children · Adolescents · Review · Cohort study · Cross-sectional study

Introduction

Epidemiological data have shown that low back pain (LBP) is not only a health problem for adults but is also frequently reported by schoolchildren [1–12]. The prevalence of LBP in children and adolescents increases with subjects' age [13–15], and females demonstrate its higher occurrence [2, 7, 16, 17]. A recent study found that the self-reported prevalence of LBP was 31%, 51.9% and 71.2% among children aged 10–13, 14–16 and 17–19 years, respectively [11]. Back pain during this period of life may have health implications in adulthood [18, 19]. The high prevalence and care seeking translate into a substantial financial burden for society. In the USA, the annual cost of chronic pain in adolescents aged 10–17 years, of which musculoskeletal pain comprised the largest proportion, was $19.5 billion [20]. In Germany, a minimum figure for direct costs for the treatment of people under the age of 25 years with back disorders is €100 million per year [21]. Given this, understanding the relation between main factors associated with LBP and prevalence of LBP is crucial.

The aetiology of back pain in children and adolescents is unknown. And furthermore, studies investigating risk factors for LBP report mostly unclear associations [22]. Studies revealed that physical activity is one of the important factors related to the risk of back pain in children and adolescents,

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and being physically active may be important in the prevention and management of LBP [23, 24]. On the other hand, there is evidence that heavy physical activity is hazardous on the back [25, 26].

The last systematic review based on the analysis of the relation between physical activity and LBP in schoolchildren was published in 2011 [27]. This review showed conflicting evidence for the association between physical activity and LBP occurrence in schoolchildren. Therefore, the analysis of the current research seems to be important to improve understanding of physical activity-related risk factors for LBP and may be important in the prevention and management of LBP in children and adolescents.

The aim of this review was to analyse the current knowledge regarding the association between physical activity and LBP among children and adolescents.

Methods

Search strategy

Publications were retrieved by searching the following databases: PubMed, The Cochrane Library, Web of Science, Medline and SportDiscus with Full Text (EBSCO). The search strategy included keywords related to physical activity and LBP. An example of the search strategy for the PubMed database is provided in Table 1. All articles published between 2011 and December 2019 were eligible for inclusion in the review.

The information sources were searched independently by two reviewers (AK and MP). The reviewers screened the identified papers and made decisions about inclusion according to the eligibility criteria. Disagreements were resolved by consensus or a third reviewer (DC). All citations were screened to identify relevant studies, firstly by title, secondly by abstract and thirdly by full-text screening. A paper was considered potentially relevant and the full text reviewed if, following discussion between the two independent reviewers, it could not be unequivocally excluded on the basis of its title and abstract [28]. The number of articles included and excluded at different phases was presented in a PRISMA flowchart (Fig. 1). PRISMA guidelines were followed for this systematic review [29].

Selection criteria

The studies were included if they met the following criteria:

- Observational study design (cohort or cross-sectional study);
- The study included males and/or females aged 9–19 years with non-specific LBP;
- The study reported estimates of the association between physical activity (exposure) and LBP (outcome).

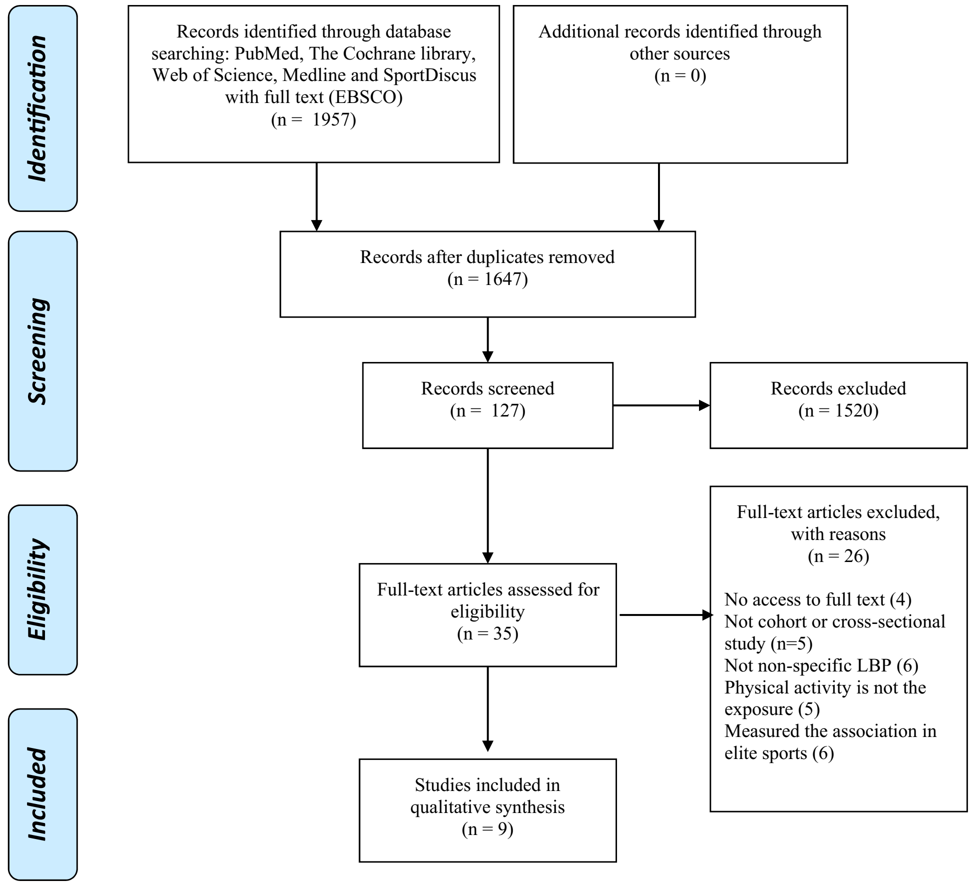
Studies were excluded if they:

- Were experimental or intervention studies;
- Used a case–control design;
- Were published in languages other than English;
- Included participants with LBP due to a specific cause such as serious pathology, fracture, herniated intervertebral disc, neurological compromise, osteoporosis, cancer or other specific causes;
- Investigated specific professional or elite sports.

Table 1 Search strategy (PubMed)

Search	Search terms
#1	"Low back pain" [Mesh]
#2	"Back pain" [Title/Abstract] OR "low back pain" [Title/Abstract] OR "lower back pain" [Title/Abstract] OR "lumbar pain" [Title/Abstract] OR "non-specific low back pain" [Title/Abstract] OR "lumbosacral pain" [Title/Abstract]
#3	# 1 OR #2
#4	"Child" [Mesh]
#5	"Adolescent" [Mesh]
#6	Child* [Text Word] OR "adolescent*" [Text Word] OR teen* [Text Word] OR schoolchildren [Text Word] OR "school children" [Text Word]
#7	#4 OR #5 OR #6
#8	"Youth Sports" [Mesh]
#9	"Physical activity" [Text Word] OR "physical activities" [Text Word] OR "activit* of daily living" [Text Word] OR "physical inactivity" [Text Word] OR "leisure activities" [Text Word] OR "level of physical activity" [Text Word] OR sport* [Text Word]
#10	#8 OR #9
#11	#3 AND #7 And #10

Fig. 1 Flowchart of the included studies in this review



Data extraction

Data were extracted independently by two reviewers (AK and MP). Disagreements were resolved through discussion between the reviewers. The extracted data included first author, year of publication, study design, study population, participant characteristics, sample size, LBP measurement tool and prevalence of LBP, physical activity type, physical activity measurement tool and main findings. The corresponding authors of eligible studies were contacted if potentially relevant data were missing.

Methodological quality assessment

The studies were assessed for methodological quality using modified checklist for quality appraisal from the previous systematic review [24]. The assessment was carried out by two reviewers (AK and MP) independently. Preceding the final screening, reviewers pilot tested the methodological quality assessment of two similar articles that were not included in this review. Disagreements were resolved by discussion or consultation with the third reviewer.

Different checklists were used for the quality assessment of different study designs (Table 2). Sixteen criteria were used to assess the methodological quality of cohort studies, and 14 criteria were applied for cross-sectional studies. Each item was rated as positive or negative (potential bias) or unclear (if description was unclear). Each study was assigned a total score, which was the sum of all positive ratings according to the methodological criteria. The reviewers considered studies to be of high quality if the methodological quality score was more than 50% of the maximum score [30]. Therefore, cohort studies scoring more than 8 and cross-sectional studies scoring more than 7 were identified as high-quality studies. Only high-quality studies were included in the review.

Strength of evidence

The strength of evidence was divided into five levels based on the study design, the number of studies and the quality score of studies [30]:

1. Strong evidence: consistent findings in at least 50% of high-quality cohort studies.
2. Moderate evidence: consistent findings in one high-quality cohort study and two or more cross-sectional studies, or at least 50% of high-quality cross-sectional studies.
3. Limited evidence: consistent findings in one high-quality cohort study or in two or more cross-sectional studies.

Table 2 Methodological quality assessment of the nine studies

Study/quality item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total score (%)	
Cohort study (C)																			
Aartun et al. [31]	1	1	1	1	1	1	1	1	1	NA	1	1	1	1	1	1	0	15/16	(94)
Kichuci et al. [35]	1	0	1	1	0	0	1	1	0	NA	1	0	0	1	1	1	0	9/16	(56)
Cross-sectional study (CS)																			
Shan et al. [39]	1	1	1	NA	0	0	1	1	1	1	NA	NA	1	1	1	1	0	11/14	(79)
Dianat et al. [33]	1	1	1	NA	0	0	1	1	0	1	NA	NA	0	1	1	1	1	10/14	(71)
Gouddal et al. [34]	1	1	1	NA	0	0	1	1	0	1	NA	NA	1	1	1	1	0	10/14	(71)
Sato et al. [37]	1	1	1	NA	1	0	1	1	0	1	NA	NA	0	1	1	1	0	10/14	(71)
Scarabottolo et al. [38]	1	1	1	NA	1	0	1	1	0	1	NA	NA	1	1	1	0	0	10/14	(71)
Bento et al. [32]	1	1	0	NA	1	0	0	1	0	1	NA	NA	1	1	1	0	0	8/14	(57)
Muntaner-Mas et al. [36]	1	1	0	NA	0	0	1	1	1	1	NA	NA	0	1	1	0	0	8/14	(57)

Studies are ranked according to their total scores, in cases of equal ranking, in alphabetical order of the first author's surname

Score interpretation: 1 = Yes, 0 = No or description was not clear. NA—not applicable

4. Conflicting evidence: inconsistent findings in multiple studies.
5. No evidence: when one cohort or cross-sectional study or no study provided findings for or against an association.

Data synthesis

Cohort studies and cross-sectional studies were assessed separately. To analyse association between LBP and physical activity, the relationship between these factors was explored and pooled if methodological homogeneity in the studies was identified. This involved making a subjective decision based on consensus between the authors. Key factors in this decision included study population, type of exposures and outcomes measured, methods of exposure assessment and data presentation. The analysis of the results was limited to qualitative summary.

Results

Search strategy

The searches retrieved 1957 studies. After removing duplicates, 1647 studies remained. Based on the analysis of the titles and abstracts, 35 studies were eligible for assessment by full paper. Of these, nine studies [31–39] fulfilled the inclusion criteria for further analysis.

The included studies comprise two cohort studies [31, 35] and seven cross-sectional studies [33, 34, 36–39]. For cohort studies, the shortest follow-up period was 2 years [31] and the longest 6 years [35]. The flow of studies through the review is depicted in Fig. 1.

Study characteristics

The total sample size of the nine included studies consisted of 75,233 subjects (ranging from 144 to 31,429 participants), with the age range of 9–19 years. All studies recruited both females and males. The characteristics of the included studies are described in Table 3. It was not possible to pool data due to heterogeneity regarding exposure (physical activity) and outcome (low back pain) measures.

The majority of the included studies ($n = 8$) used questionnaires to measure physical activity level, and only one study used objective measurements of physical activity (GT3X triaxial accelerometer) [31]. Six studies examined leisure-time physical activity [33–37, 39]. Three studies assessed daily physical activity [31, 32, 38]. All of the included studies adopted different classifications of physical activity levels taking into account the intensity of physical activity, the frequency of physical activity each week and the average time of each physical activity.

The prevalence of LBP episodes was measured by the use of a questionnaire [31–39], of which two studies used standardized Nordic questionnaire [32, 38]. In six of the studies, the authors gave information on the validation and/or reproducibility of the questionnaires [31–34, 38, 39].

Associations have been most widely expressed by odds ratios or relative risks.

Methodological quality assessment

The scoring of the two reviewers of the included studies had an agreement rate of 91% (29/32) for cohort studies and 89% (88/98) for cross-sectional studies. All disagreements were resolved during a consensus meeting. The results of the methodological quality appraisal are presented in Table 2.

Table 3 Characteristics of the included studies

Study	Design	Age group	Sample size	Measurement of LBP	Physical activity	Measurement of physical activity	Main findings
Cohort studies							
Aartun et al. [31]	2-year prospective cohort study	11–13 years	Baseline: 1291, FU: 144 60 girls 84 boys	Questionnaire: LBP "often", "sometimes", "once or twice"	Activity levels: sedentary 0–100 cpm; light 101–2295 cpm; moderate 2296–4011 cpm; vigorous 4012–50 000 cpm	GT3X triaxial accelerometer	The proportion of the day spent at different physical activity levels did not predict the incidence of spinal pain. However, the participants in the highest proportion of the day spent in vigorous physical activity were at an increased risk for reporting an episode of spinal pain at follow-up (crude RR = 1.26; 95% CI 1.00–1.58)
Kikuchi et al. [35]	Cohort study followed for 6 years	9–15 years Grade E4–Eg, J1–J3	Baseline: 32,596 FU6: 31,419 16,052 girls 15,367 boys	Questionnaire: LBP now	Extracurricular sport activities (ECSA): ECSA (−), ECSA (+)	Questionnaire	LBP was more prevalent in the ECSA group than in the non-ECSA group in almost every grade, regardless of gender; the difference was significant in some but not all grades
Cross-sectional studies							
Bento et al. [32]	Cross-sectional study	15–18 years	1628: 830 girls 798 boys	Nordic questionnaire, which was adapted to the Brazilian culture. LBP in the past year	Levels of physical activity: very active, sufficiently active, insufficiently active	The Baecke questionnaire of habitual physical activity	There was no association between LBP and physical activity: Sufficiently active: PR = 0.97; 95% CI 0.86–1.11) Insufficiently active: PR = 0.95; 95% CI 0.82–1.10)

Table 3 (continued)

Study	Design	Age group	Sample size	Measurement of LBP	Physical activity	Measurement of physical activity	Main findings
Dianat et al. [33]	Cross-sectional study	11–14 years	1611: 860 girls 751 boys	Questionnaire: LBP during the past month	Physical leisure activity: playing sport (hours/week): < 1 h/wk; 1–3 h/wk; > 3 h/wk	Questionnaire	Leisure-time physical activity (time spent on sport activities) was not associated with LBP Playing sport 1–3 h/wk: OR = 0.83 (95% CI 0.65–10.07) Playing sport > 3 h/wk: OR = 0.84 (95% CI 0.65–1.08)
Guddal et al. [34]	Cross-sectional study.	13–19 years	7596: 3831 girls 3765 boys	Questionnaire: LBP during the past 3 months	Three categories of physical activity, regardless of type of sport: "low activity" represented 1 day a week or less, "moderate activity" represented 2–3 days a week, "high activity" represented 4 days a week or more. Sport participation: (1) ">/= 1 time per week" was defined as active participation in the respective sport; (2) "never" or "< 1 time per week" were used as inactive groups	The question adopted from the World Health Organization Health Behaviour in Schoolchildren (HBSC) questionnaire	Compared with a low PA level, a moderate PA level was significantly associated with decreased odds of LBP among both girls and boys (OR = 0.77; 95% CI 0.60–0.98, and OR = 0.70; 95% CI 0.51–0.95, respectively)
Muntaner-Mas et al. [36]	Cross-sectional study	10-12 years Fifth- and sixth-grade primary school students	2032: 943 girls, 1089 boys	Questionnaire: "lifetime LBP" (never, almost never or sometimes) "severe LBP" (often or always)	Sports participation (outside school hours): < 2/wk; 2–4 h/wk; > 4 h/wk	Questionnaire	Children who spent > 4-h doing sport were more likely to have lifetime LBP (OR = 1.6; 95%CI 1.19–2.17) and not severe LBP than those who did not do any sport.

Table 3 (continued)

Study	Design	Age group	Sample size	Measurement of LBP	Physical activity	Measurement of physical activity	Main findings
Sato et al. [37]	Cross-sectional study	9–15 years Grade E4–Eg, J1–J3	26,766: 12,430 girls 14,336 boys	Questionnaire: LBP now and before	Sports activities other than school physical education classes (hours/week): No sports group Sports group: < 6 h/wk; 6–12 h/wk; > 12 h/wk	Questionnaire	Sports activities increased the risk of LBP (OR = 1.57; 95% CI 1.45–1.70)
Scarabottolo et al. [38]	Cross-sectional study	10–17 years	1011: 557 girls, 454 boys	The Nordic questionnaire: LBP in the previous 7 days	Habitual physical activity through three different domains: physical activity at school; occupational physical activity; sports activities outside school (related to sports practice).	The Baecke physical activity questionnaire	Adolescents inactive in occupational activities were more likely to have LBP (OR = 1.43; 95% CI 1.03–2.00) Adolescents inactive in sports activities were more likely to have LBP (OR = 1.37; 95% CI 0.97–1.95)
Shan et al. [39]	Cross-sectional study	15–19 years	3016: 1556 girls, 1460 boys	Questionnaire: LBP during the past six months	Extracurricular activities (physical activity after school): (1) the intensity of regular physical activity—light, moderate, heavy (2) the frequency of physical activity each week—once a week or less, 1–4 times a week, 5–7 times a week, more than 5–7 times a week (3) the average time of each physical activity - < 0.5 h, 0.5–1 h, 1–2 h, > 2 h	Questionnaire	The group who engaged in physical activity 1–4 times weekly showed significantly less LBP (OR = 0.76; 95% CI 0.64–0.90) than those who did so for longer or shorter periods The group that exercised for approximately longer that 2 h each day showed significantly more often prevalence LBP than those who did so for shorter periods (OR = 1.13; 95% CI 0.73–1.76)

LBP Low back pain, *RR* related risk, *OR* odds ratio, *PR* prevalence ratio

For the cohort studies, the mean score for methodological quality was 75%. The mean score for methodological quality of cross-sectional studies was 68% with a range of 57–79%. Two cohort studies were rated as high-quality studies. Seven cross-sectional studies were rated as high-quality studies. All the studies that were eligible to be included in the analysis were assessed to be of high quality.

Cohort studies

One cohort study showed that objectively measured physical activity (using the accelerometer) in 11–13-year-old adolescents was generally not predictive of LBP prevalence [31]. Proportion of the day spent at different physical activity levels did not predict the incidence of spinal pain. Physical activity did not affect the risk of spinal pain, but the 10% most active adolescents were at increased risk of developing spinal pain. Thus, vigorous physical activity appears to be a risk factor for spinal pain in adolescents [31]. The other cohort study found an association between activity and LBP [35]. LBP was more prevalent in the extracurricular sports activities group than in the non-extracurricular sports activities group in almost every grade, regardless of gender [35]. The results from cohort studies are summarized in Tables 3 and 4.

Cross-sectional studies

Five studies found an association between physical activity and LBP in children and adolescents [34, 36–39]. Two studies [34, 38] reported that a low level of physical activity is a risk factor for LBP occurrence. Another study found that the group who engaged in physical activity 1–4 times weekly showed significantly less LBP than those who did so for longer or shorter periods [39]. And moreover, three studies [36, 37, 39] found that a high level of physical activity is associated with high prevalence of LBP. One study found that children who spent ≥ 4 h per week doing sport

Table 4 Results from studies included in the review

Study	Design	Sample size	Exposure	Outcome	Finding
Aartun et al. [31]	2-year prospective cohort study	144	Daily PA	LBP	No association The highest proportion of the day spent in vigorous physical activity—increased risk: RR = 1.26; 95% CI 1.00–1.58
Kikuchi et al. [35]	Cohort study followed for 6 years	31,419	PA at leisure time	LBP	Association: LBP was more prevalent in the ECSA group than in the non-ECSA
Bento et al. [32]	Cross-sectional study	1628	Daily PA	LBP	No association
Dianat et al. [33]	Cross-sectional study	1611	PA at leisure time	LBP	No association
Guddal et al. [34]	Cross-sectional study	7596	PA at leisure time	LBP	Association: moderate PA—decreased odds: OR = 0.77; 95% CI 0.60–0.98 (girls) and OR = 0.70; 95% CI 0.51–0.95 (boys)
Muntaner-Mas et al. [36]	Cross-sectional study	2032	PA at leisure time	LBP	Association: high PA—increased odds OR = 1.6; 95% CI 1.19–2.17
Sato et al. [37]	Cross-sectional study	26,766	PA at leisure time	LBP	Association: sports activities—increased odds: OR = 1.57; 95% CI 1.45–1.70
Scarabottolo et al. [38]	Cross-sectional study	1011	Daily PA	LBP	Association: Inactive in occupational activities—increased odds: OR = 1.43; 95% CI 1.03–2.00 Inactive in sports activities—increased odds: OR = 1.43; 95% CI 1.03–2.00
Shan et al. [39]	Cross-sectional study	3016	PA at leisure time	LBP	Association: Physical activity 1–4 times weekly—decreased odds: OR = 0.76; 95% CI 0.64–0.90 Exercised longer that 2 h each day—increased odds: OR = 1.13; 95% CI 0.73–1.76

PA Physical activity, *LBP* low back pain, *RR* related risk, *OR* odds ratio were more likely to have lifetime LBP [36]. Another study reported that the group that exercised for approximately longer that 2 h each day showed significantly more often prevalence LBP than those who did so for shorter periods [39]. The results from cross-sectional studies are summarized in Tables 3 and 4.

Of seven high-quality cross-sectional studies, two studies did not find an association between LBP and daily physical activity [32] or leisure-time physical activity [33, 37].

To sum up, there was moderate evidence for the association between physical activity and LBP.

Discussion

In this review, we explored the most recent literature on the association between physical activity and LBP occurrence in schoolchildren. In the final analysis, we have included nine studies. Evidence from two cohort studies supported the findings from seven cross-sectional studies. This systematic review provides moderate evidence for the association between physical activity and LBP in children and adolescents. One cohort study [35] and five cross-sectional studies [34, 36–39] found an association between physical activity and LBP in children and adolescents. The remaining studies ($n = 3$) found no relationship between physical activity and LBP.

These findings showed that both extremes of activity levels (i.e. being very low and very high physically active) are associated with LBP. Our results correspond to the results in the study by Heneweer et al. [25]. They concluded that the correlation between back pain and physical activity may be *U* shaped. Both a sedentary lifestyle and high-intensity physical activity increased the risk of back pain. The authors concluded that it was the quality, not the quantity of physical activity that was significant [25]. It is possible that different dimensions of recreational and sport-related activities may have different relationship with LBP. It seems that some types of sports can be beneficial or harmful in developing or protecting against LBP in children and adolescents. Sports activities are characterized by a mixture of different back loading forces, so specific sport activities may be detrimental to the spine. The risk of LBP associated with intensive sports practice during childhood should be explored in future studies.

Based on the limited number of studies and their heterogeneity, the results indicated moderate but not strong evidence for the association between physical activity and LBP.

One of the possible explanations for inconsistent findings among studies may relate to heterogeneity in methods of exposure assessment among studies. Most of the included studies focused on physical activity only at leisure time, which may not reflect actual daily physical activity. Physical activity during PE should be assessed and included as part of daily physical activity. Only three studies [31, 32, 38] focused on the association between daily habitual physical activities and LBP. And furthermore, a variety of PA measures were used. Most of the studies under examination used questionnaires in measuring physical activity that may produce recall bias in the estimation. To assess the physical activity level in participants with musculoskeletal pain, an objective measure is a preferable measurement device to self-report measurement [40]. Only one out of nine included studies used objective instrument (accelerometer) to assess physical activity level [31]. One of the problems is that objective methods were found to report different results than those obtained from subjective methods. Measurements and classifications of physical activity in terms of frequency, intensity and duration differed across the studies, which may lead to the misclassification of physical activity levels. The intensity of the physical activities must be further clarified with future research.

Another issue is related to the definition of LBP and validity of the exposure measurement. Only two studies provided a definition of LBP [32, 36]. In 5 studies [31–33, 38, 39], a diagram showing the location of LBP was used, which, in the case of younger children, is indispensable for better understanding of the question and providing a proper answer. The studies qualified for the review dealt with a very broad period of the occurrence of LBP. The studies asked about the occurrence of LBP in the period of the last 7 days [38], in the last month [33], the last 3 months [34], the last 6 months [39] and the last year [32]. In three studies, the question regarded whole life span [36, 37] or a current state [35, 37]. One study did not include information in which period LBP occurrence was analysed [31]. Different definitions of LBP may also result in various estimates of prevalence. Moreover, a large proportion of studies did not provide variables characterizing LBP (e.g. gender, intensity, frequency), or the inclusion or exclusion criteria for a group with LBP and without LBP. Most studies in this review did not divulge whether participants with spinal diseases which may cause LBP were excluded from the study. We therefore suggest that future studies should specifically exclude these participants. Moreover, all the included studies used questionnaires in measuring the occurrence of LBP. In most studies, self-administered questionnaires were used. In two studies, information on symptoms was collected with the standardized Nordic questionnaire (or adaptation thereof) for the analysis of musculoskeletal symptoms and this questionnaire has been considered an international standard [41]. Seven studies used a validated questionnaire [31–34, 38, 39].

Our results correspond to the results in the review by Sitthipornvorakul et al. [27]. Previous review showed conflicting evidence for the association between physical activity and LBP [27]. There is still no strong evidence for association between physical activity and LBP in children and adolescents.

Limitations

There are some limitations associated with this review. First, most included studies used self-administered questionnaires in measuring physical activity that likely produce recall bias in the estimation. Second, it is noteworthy that definitions of LBP varied widely. Moreover, we summarized the results from studies with substantial heterogeneity. We found heterogeneity among studies as to aspects such as study design, study population, type of exposures and outcomes measured, methods of exposure assessment and data presentation which may limit the final conclusions. Finally, the search strategy was limited only to fully reported publications in English.

Study strengths

This is the first review in focused not only to the heterogeneity regarding the measurement of physical activity which was highlighted in previous systematic reviews, but also to heterogeneity of the analysis of LBP prevalence. In this review, we focused on data from cohort studies that investigated physical activity characteristics and the risk of low back pain, yet also included cross-sectional studies to capture all possible relevant information on the topic. This systematic review is based on the sensitivity analysis of only very high-quality studies. The strength of evidence was divided into five levels.

Conclusion

Based on the evidence from two cohort studies and seven cross-sectional studies, there is moderate evidence for the association between physical activity and LBP in children and adolescents. The results highlight the need for continued research. It seems that for clear evaluation of the analysed association the prospective cohort studies should be conducted. The design of future studies may be improved by taking into account a number of methodological limitations that are present in the published review.

Author's contribution AK, MP and PK designed the research; AK and MP performed the research; AK, MP and DC analysed the data; AK, MP and PK wrote the paper; DC supervised the paper; and all authors read and approved the final manuscript. The authors have read the PRISMA 2009 Checklist, and the manuscript was prepared and revised according to the PRISMA 2009 Checklist.

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Conflict of interest The authors declare that they have no conflict of interest.

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