Physical Activity Level and Sport Participation in Relation to Musculoskeletal Pain in a Population-Based Study of Adolescents

The Young-HUNT Study

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Background: Prevalence of musculoskeletal pain among adolescents is high, and pain in adolescence increases the risk of chronic pain in adulthood. Studies have shown conflicting evidence regarding associations between physical activity and musculoskeletal pain, and few have evaluated the potential impact of sport participation on musculoskeletal pain in adolescent population samples.

Purpose: To examine the associations between physical activity level, sport participation, and musculoskeletal pain in the neck and shoulders, low back, and lower extremities in a population-based sample of adolescents.

Study Design: Cross-sectional study; Level of evidence 4.

Methods: Data from the Nord-Trøndelag Health Study (Young-HUNT3) were used. All 10,464 adolescents in the Nord-Trøndelag county of Norway were invited, of whom 74% participated. Participants were asked how often they had experienced pain, unrelated to any known disease or acute injury, in the neck and shoulders, low back, and lower extremities in the past 3 months. The associations between (1) physical activity level (low [reference], medium or high) or (2) sport participation (weekly compared with no/infrequent participation) and pain were evaluated using logistic regression analyses, stratified by sex, and adjusted for age, socioeconomic status, and psychological distress.

Results: The analyses included 7596 adolescents (mean age, 15.8 years; SD, 1.7). Neck and shoulder pain was most prevalent (17%). A moderate level of physical activity was associated with reduced odds of neck and shoulder pain (OR = 0.79 [95% CI, 0.66-0.94]) and low back pain (OR = 0.75 [95% CI, 0.62-0.91]), whereas a high level of activity increased the odds of lower extremity pain (OR = 1.60 [95% CI, 1.29-1.99]). Participation in endurance sports was associated with lower odds of neck and shoulder pain (OR = 0.79 [95% CI, 0.68-0.92]) and low back pain (OR = 0.77 [95% CI, 0.65-0.92]), especially among girls. Participation in technical sports was associated with increased odds of low back pain, whereas team sports were associated with increased odds of lower extremity pain. Strength and extreme sports were related to pain in all regions.

Conclusion: We found that a moderate physical activity level was associated with less neck and shoulder pain and low back pain, and that participation in endurance sports may be particularly beneficial. Our findings highlight the need for health care professionals to consider the types of sports adolescents participate in when evaluating their musculoskeletal pain.

Keywords: musculoskeletal pain; physical activity; sport participation; adolescents; overuse problems; epidemiology

There is growing awareness of the challenges created by the increasingly high prevalence of musculoskeletal pain among adolescents.[7,15,21] Musculoskeletal pain may result in reduced quality of life, absence from school, and increased use of pharmaceuticals and health care.[11,32] In most studies, girls report higher prevalence of pain symptoms.[2,3,30,33] Adolescents with musculoskeletal pain tend to have a higher risk of chronic pain in adulthood,[18,41]

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emphasizing the importance of forming a better understanding of potential determinants of pain.

It is well documented that engagement in sports increases the risk of acute injuries. High levels of physical activity (PA) and sports participation have also been suggested as risk factors for nontraumatic musculoskeletal pain; however, the evidence is inconsistent.[42] Some studies have found an increased risk of musculoskeletal pain in adolescents with high levels of PA.[2,24,33,36] Others have reported that PA is associated with reduced risk of musculoskeletal pain,[30,44,47] and some report no association between PA and back pain[1,5,29,48] or other musculoskeletal pain.[9] It is difficult to compare results from various studies as definitions of pain and distinctions between traumatic and nontraumatic musculoskeletal pain vary. Furthermore, few have differentiated according to localization of musculoskeletal pain. Previous studies have primarily been conducted in selected samples, and evaluation of PA has been limited; most studies capture the frequency of PA but lack information about type of sport participation.

As different sports are likely to have diverse effects on the etiology and pathogenesis of musculoskeletal pain due to variations in physical strain and loading, it is important to evaluate these relationships. Knowledge about the potentially positive or negative impact of different types of sports on musculoskeletal pain, and how this may vary between different pain locations, will help guide and develop future preventive strategies.

To our knowledge, only 1 former population-based study has evaluated the potential impact of sports on musculoskeletal pain in an adolescent population sample. They found that participation in gym training, downhill skiing, snowboarding, and gymnastics was related to neck, shoulder, and low back pain.[3] More research is available on overuse injuries potentially causing long-term pain in adolescent athlete populations, with the highest prevalence reported in sports requiring repetitive movements of the lower extremities such as track and field and soccer.[38,40] In addition to pain conditions in the lower extremities, the low back and shoulders are the most commonly reported pain locations in adolescents participating in sports.[8,26]

As the relationship between PA and musculoskeletal pain in each of these 3 common pain locations has not previously been explicitly studied, we wanted to explore these relationships while taking into account the specific types of sports adolescents reported performing.

The aim of this study was to examine the association between level of leisure time PA or sport participation and musculoskeletal pain, unrelated to any known disease or acute injury, in the neck and shoulder (NSP), low back (LBP), and lower extremities (LEP) among adolescents in a population-based sample.

METHODS

Study Sample

All adolescents (N = 10,464) aged 13 to 19 years in the Nord-Trøndelag county of Norway were invited to participate in the third population-based Nord-Trøndelag Health Study (Young-HUNT3), conducted from 2006 to 2008. Attendees completed a comprehensive health-related questionnaire during school hours. The questionnaire included an invitation to a subsequent clinical examination. Adolescents who were absent from school were invited to participate via post. A total of 7716 (74%) adolescents responded to the questionnaire and attended the clinical examination. Of these, 120 participants were excluded due to age $\geq$20 years or because they did not respond to the pain questions of interest (Appendix Figure A1).

Exposure Variables

The level of leisure time PA was assessed by asking: "Not during the average school day; how many days a week do you play sports or exercise to the point where you breathe heavily and/or sweat?" The 7 response alternatives were the following: every day, 4 to 6 d/wk, 2 to 3 d/wk, 1 d/wk, less than every week, less than every month, and never. The responses were divided into 3 categories of PA, regardless of type of sport: "Low activity" represented 1 day a week or less, "moderate activity" represented 2 to 3 days a week, and "high activity" represented 4 days a week or more. The question was adopted from the World Health Organization Health Behaviour in Schoolchildren (HBSC) questionnaire and has been found to hold acceptable reliability and validity.[35]

Sport participation was assessed by asking: "How often have you participated in the following activities/sports in the past 12 months?": endurance sports, team sports, strength sports, technical sports, esthetic sports, martial arts, extreme sports, jogging or walking/hiking, and other (Table 1). The response options were not mutually exclusive. Frequency of each sport/activity was measured according to the answer options: never, <1, 1, or several times per week. A dichotomous variable was created for each of the sport categories, where a frequency of "$\geq$1 time per week" was defined as active participation in the respective sport. Participants who responded "never" or "<1 time per week" in each of the sport categories were used as reference groups. As a vast majority of individuals in our sample engaged in jogging and hiking, these common activities were not regarded as individual sport exposures.

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TABLE 1
Characteristics of the Study Sample (N = 7596)

Variables	Girls (n = 3831)	Boys (n = 3765)
Age, y, mean (SD)	15.8 (1.7)	15.8 (1.7)
Physical activity, n (%)		
High physical activity	1379 (36.0)	1717 (45.6)
Moderate physical activity	1441 (37.6)	1179 (31.3)
Low physical activity	962 (25.1)	834 (22.2)
Missing	48 (1.3)	35 (0.9)
Sport participation,[a] n (%)		
Endurance sports[b]	1756 (45.8)	1924 (51.1)
Team sports[c]	2251 (58.8)	2354 (62.5)
Strength sports[d]	928 (24.2)	1482 (39.4)
Technical sports[e]	905 (23.6)	924 (24.5)
Esthetic sports[f]	1009 (26.3)	218 (5.8)
Martial arts[g]	149 (3.9)	286 (7.6)
Extreme sports[h]	35 (0.9)	174 (4.6)
Psychological distress,[i] mean (SD)	1.6 (0.6)	1.3 (0.4)
Missing, n (%)	77 (2.0)	142 (4.0)
Family economy, n (%)		
Above average	565 (14.7)	722 (19.2)
Average	2721 (71.0)	2471 (65.6)
Below average	355 (9.3)	276 (7.3)
Missing	190 (5.0)	296 (7.9)
Body mass index, kg/m^2, mean (SD)	22.2 (3.7)	22.1 (3.9)

[a]Participation in each of the sport categories ≥1 d/wk.
[b]For example, cross-country skiing, swimming, running.
[c]For example, soccer, volleyball, handball.
[d]For example, weightlifting, bodybuilding.
[e]For example, track and field, Alpine skiing, snowboarding.
[f]For example, dance, gymnastics.
[g]For example, judo, karate, boxing.
[h]For example, rafting, rock climbing, paragliding.
[i]Range of possible scores is 1 to 4.

Outcome Variables

The outcomes of interest in the present study were NSP, LBP, and LEP. Musculoskeletal pain was assessed using respondents' reports of how often they had experienced pain unrelated to any known disease or acute injury during the past 3 months. Pain in the neck and shoulders, low back, and lower extremities were listed among several possibilities. The frequency of pain in each location was specified using 5 alternatives ranging from "never or seldom" to "almost every day." Reported pain frequency of "≥1 day per week" was used as a cutoff point to distinguish between the adolescents who experienced pain frequently and those who experienced pain rarely. The reference group in the analyses was adolescents who reported experiencing musculoskeletal pain "never or seldom" or "less than once a month." Good test-retest reliability (kappa [κ] = 0.9) evaluated by repeating the questions about occurrence of musculoskeletal pain (≥1 day per week) at a 1-week interval, as well as good concurrent validity investigated by comparisons with interviews (κ = 0.7), have previously been demonstrated for the pain questionnaire.[28]

Background Variables and Confounders

Data on sex and age were obtained from the Norwegian National Population Registry. Socioeconomic status was based on perceived family economy (above average, average, or below average). Psychological distress, including symptoms of anxiety and depression, was measured using a validated 5-item short version of the Hopkins Symptom Check List (SCL-5).[43] Responses to various mental health complaints fear or anxiety; tension, distress, or restlessness; hopelessness about the future; sadness; and excessive worry during the past 2 weeks) were scored according to 4 alternatives ranging from "not at all bothered" (1) to "extremely bothered" (4), and a mean score was calculated (1.6 for girls and 1.3 for boys). Body mass index (BMI) was used as a continuous variable.

Ethics

The HUNT studies are approved by the Data Inspectorate of Norway and by the Regional Committee for Medical Research Ethics, and all information from HUNT is treated according to the guidelines of the Data Inspectorate. Participation is based on informed consent from participants aged 16 years or older. In accordance with Norwegian law, parents of those younger than 16 years consented on behalf of their child.

Statistical Analysis

Continuous variables were described with means and standard deviations (SDs) and categorical variables using counts and percentages. Differences in distribution of the baseline characteristics of girls and boys were calculated using the chi-square test for categorical variables and the Student *t* test for continuous variables.

Logistic regression analyses were used to estimate the association between (1) level of PA (low [reference], medium, or high) or (2) weekly sport participation compared with no or infrequent participation and NSP, LBP, and LEP. Analyses were stratified by sex. The results were reported as crude and adjusted odds ratios (ORs) with 95% confidence intervals (CIs). Potential confounders were selected based on a priori knowledge and previous studies. Adjustments were made for age, BMI, socioeconomic status, and psychological distress. However, BMI did not alter the magnitude or direction of the associations between PA or sport participation and pain and was therefore removed from the final model. The exposure variables (1) level of PA and (2) type of sport participation were analyzed in separate models. The 7 categories of sport participation were all adjusted for each other. Sports performed by fewer than 30 participants in each of the 3 pain categories were excluded in the presentation of the results (extreme sports for girls and esthetic sports for boys). Some individuals reported pain in more than 1 location, thus introducing statistical dependencies into our data. Therefore, we performed additional sensitivity analyses for participants reporting pain in only 1 of the pain locations (NSP, LBP, or LEP). *P* values <.05 were considered statistically significant. All tests were

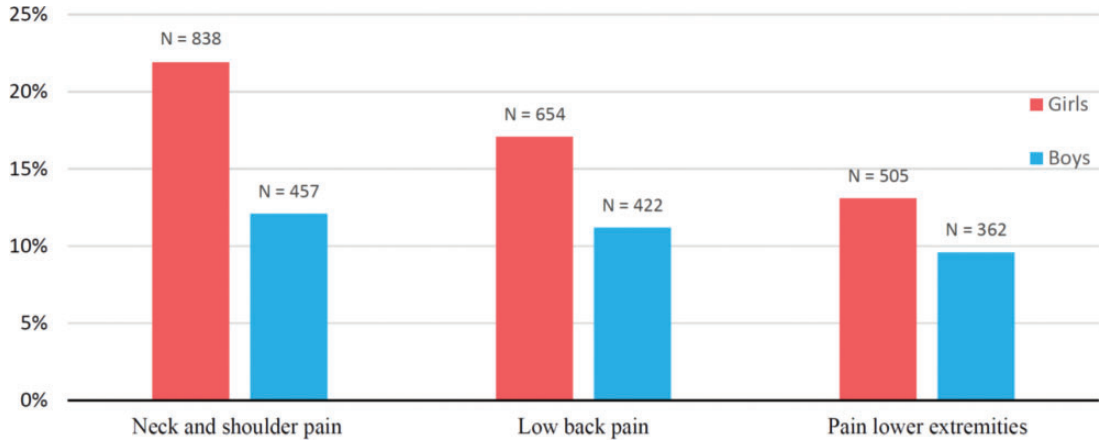

Figure 1. Reported frequency of persistent weekly pain in the neck and shoulders (NSP), low back (LBP), and lower extremities (LEP), stratified by sex (n = 7596).

2-sided. All analyses were performed using SPSS version 21 (IBM Corp).

RESULTS

The analyses included 3831 girls and 3765 boys, with a mean age of 15.8 years (SD, 1.7).

In total, 84% reported participating in some sort of sport at least once a week. Boys reported a higher participation rate in all sports except for esthetic sports. High or moderate levels of PA were reported by 75% of participants, with more boys than girls reporting a high level of PA ($P < .001$) (Table 1). More girls than boys reported pain in each of the body locations ($P < .001$), and NSP was the most frequent pain location reported for both sexes (Figure 1). The majority of both boys and girls (62%) reported pain in only 1 of the 3 body locations. However, 17% of girls and 12% of boys reported both NSP and LBP.

Associations Between PA Level and Pain Outcomes

Compared with a low PA level in crude and adjusted analyses, a moderate PA level was significantly associated with decreased odds of NSP among both girls and boys (OR = 0.79 [95% CI, 0.63-0.99] and OR = 0.74 [95% CI, 0.55-1.00], respectively), and decreased odds of LBP (OR = 0.77 [95% CI, 0.60-0.98] and OR = 0.70 [95% CI, 0.51-0.95], respectively). A high PA level was associated with slightly decreased odds of NSP and LBP, although results were not significant. In contrast, a high PA level was significantly associated with increased odds of LEP among both girls (OR = 1.39 [95% CI, 1.05-1.85]) and boys (OR = 2.06 [95% CI, 1.44-2.95]) (Appendix Table A1). The sensitivity analyses of those reporting only 1 pain outcome revealed similar results.

Associations Between Sport Participation and Pain Outcomes

Neck and Shoulder Pain. Weekly participation in endurance sports, compared with infrequent or no participation, was associated with reduced odds of NSP for both sexes. Among boys, team sports were related to reduced odds of NSP, whereas strength sports (OR = 1.32 [95% CI, 1.03-1.71]) and extreme sports were associated with increased odds of NSP (OR = 2.31 [95% CI, 1.40-3.82]) (Figure 2).

Low Back Pain. Among girls, weekly participation in endurance sports, as compared with infrequent or no sport participation, was related to decreased odds of LBP (OR = 0.70 [95% CI, 0.56-0.88]). Technical sports were the only type of sport associated with LBP (OR = 1.43 [95% CI, 1.11-1.83] in girls and OR = 1.33 [95% CI, 1.00-1.76] in boys) (Figure 3). In unadjusted analyses, however, performing strength sports, martial arts, and extreme sports also significantly increased the odds of LBP among boys (OR = 1.36 [95% CI, 1.08-1.72], OR = 1.54 [95% CI, 1.06-2.24], and OR = 1.78 [95% CI, 1.11-2.85], respectively).

Lower Extremity Pain. None of the sports were significantly associated with reduced odds of LEP. Participation in strength sports and technical sports, versus no or infrequent participation, was associated with increased odds of LEP among girls. Among boys, participating in team sports was associated with LEP (OR = 1.69 [95% CI, 1.24-2.30]), while those participating in extreme sports were more than twice as likely to experience LEP compared with nonparticipants (Figure 4).

Sensitivity analyses of those reporting only NSP, LBP, or LEP confirmed the results presented above. However, the analysis of participants with "only LEP" did reveal stronger and significantly increased odds of LEP in both girls (OR = 1.41 [95% CI 1.02-1.94]) and boys (OR = 1.91 [95% CI, 1.25-2.91]) who participated in team sports.

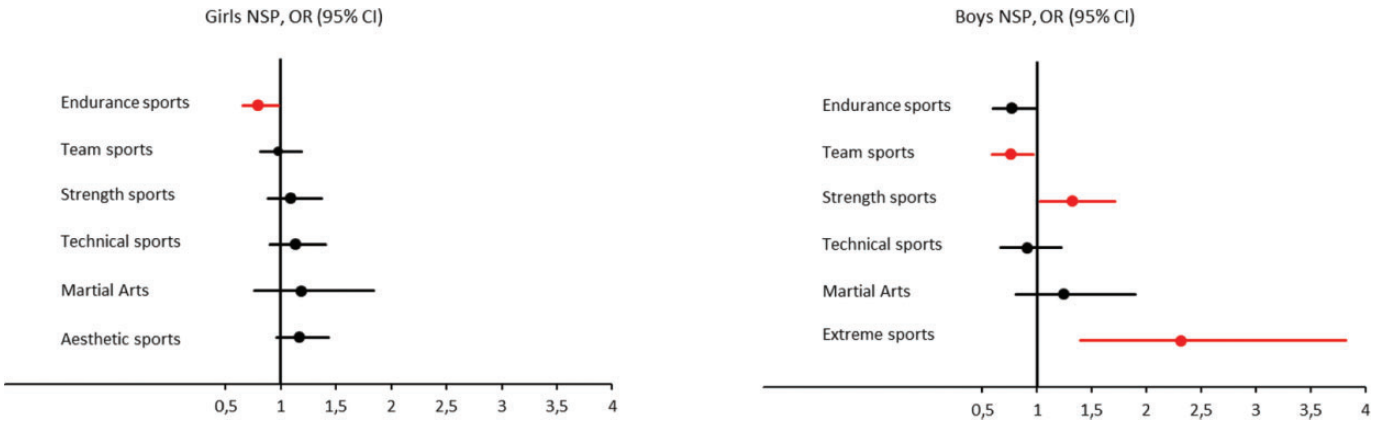

Figure 2. The odds ratio (OR) with 95% CI of persistent weekly neck and shoulder pain (NSP) related to sport participation in girls and boys. Analyses adjusted for age, socioeconomic status, psychological distress, and participation in other sports. Reference groups were participants who responded "never" or "≤1 time per week" in each of the sport categories.

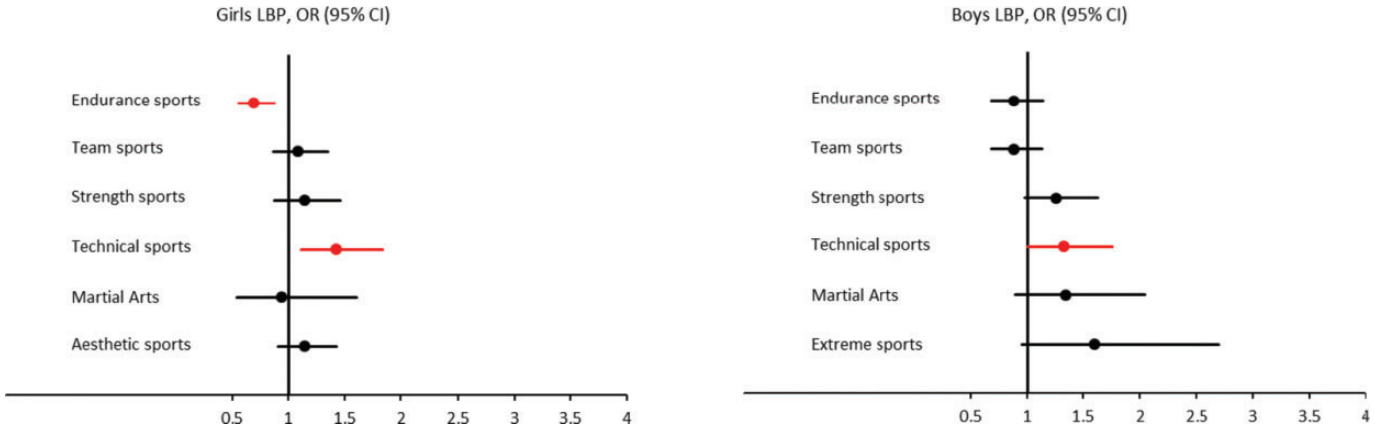

Figure 3. The odds ratio (OR) with 95% CI of persistent weekly low back pain (LBP) related to sport participation in girls and boys. Analyses adjusted for age, socioeconomic status, psychological distress, and participation in other sports. Reference groups were participants who responded "never" or "≤1 time per week" in each of the sport categories.

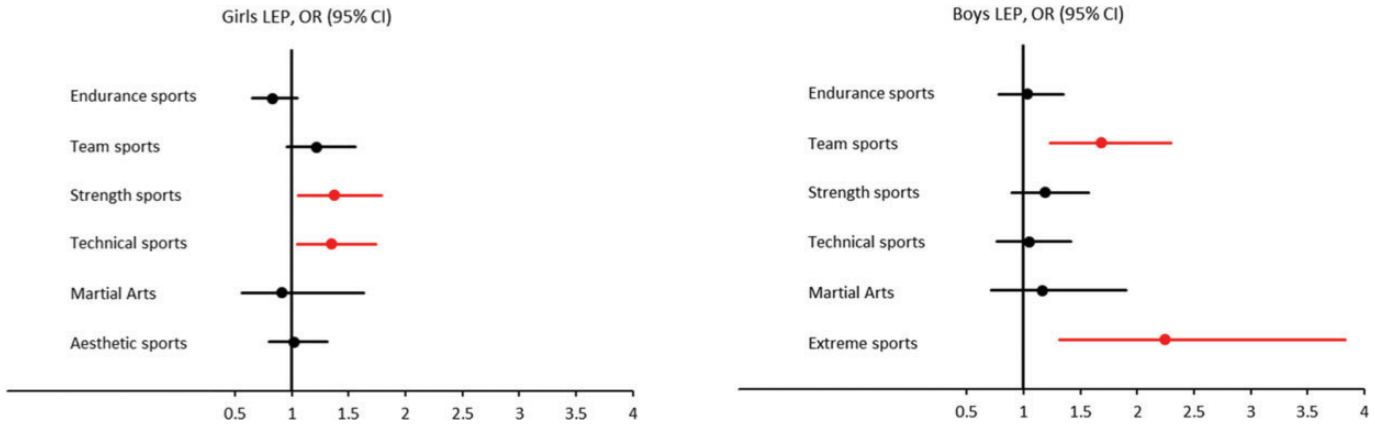

Figure 4. The odds ratio (OR) with 95% CI of persistent weekly lower extremity pain (LEP) related to sport participation in girls and boys. Analyses adjusted for age, socioeconomic status, psychological distress, and participation in other sports. Reference groups were participants who responded "never" or "≤1 time per week" in each of the sport categories.

DISCUSSION

In this population-based study of adolescents, we found that a moderate PA level was associated with reduced odds of NSP and LBP, whereas a high level of PA was associated with increased odds of LEP. Endurance sports were found to be associated with reduced odds of NSP and LBP, especially among girls. Team sport participation was associated with increased odds of LEP, whereas technical sports were related to greater odds of LBP for both sexes.

In line with previous results from adolescent population-derived cohorts,[2,30] a moderate level of PA was associated with reduced odds of NSP and LBP for both sexes. However, in a population-based sample of Danish adolescents, self-reported PA was not associated with LBP.[5]

In the current study, a high level of PA was associated with LEP but not NSP or LBP. Most sports-related overuse injuries occur in the lower extremities[10,38] and are typically due to repetitive submaximal loading of the musculoskeletal system without adequate rest to allow for structural adaptation to take place.[6,10] In a large study of adolescent athletes, overuse injuries in the lower extremities accounted for 62.6% of all overuse injuries.[40] It is well documented that young athletes often continue with training and competition without reductions in training volume, despite the existence of overuse problems.[8] Thus, one should be aware that the threshold to reduce the frequency of PA might be high for active adolescents who are experiencing musculoskeletal pain due to overuse. Based on the current results, and due to the higher risk of overuse-related problems in the lower extremities, it may be particularly important for coaches and health care professionals to provide information regarding PA modifications to adolescents who report pain in the lower extremities.

Regarding the potential contribution of various types of sports, we found that participation in endurance sports was associated with reduced odds of NSP. The only former population-based study within the field[3] found that cross-country skiing, a typical endurance sport in Norway, was associated with lower prevalence of both NSP and LBP. They argued that this beneficial effect was due to the versatile nature of the sport. Furthermore, participating in sports loading the upper extremities has been associated with low prevalence of NSP, as reported in both cross-sectional[31] and longitudinal[41] studies.

Endurance sports were also significantly associated with reduced prevalence of LBP among girls in the current study. Auvinen et al[3] found that cross-country skiing specifically could protect against LBP. Furthermore, Clarsen et al[8] reported a low rate of low back problems among adolescent cross-country skiers compared with athletes in other sports. As back pain has been associated with low isometric muscle endurance in the back extensors among adolescents,[5] this could be part of the explanation for the possible beneficial effect of endurance sports. Even at a high level, endurance sports do not seem to be harmful to the back. Among former elite endurance athletes (cross-country skiing, rowing, and orienteering), LBP was no more common than among nonathletes, and orienteering was found to be protective.[14]

Auvinen et al[3] reported that strength training was associated with increased LBP in adolescents. The same association was found among boys in the current study, although results were not significant in the adjusted analysis. Several studies have reported that LBP is the most frequent complaint in adolescent athletes who participate in strength training,[12] and the use of weight training machines in particular has been found to increase the risk of LBP.[39] Furthermore, hyperextension or rotational motions causing repetitive stress to the spine are reported to be risk factors for back pain among adolescents participating in various technical sports.[17] In line with this, performing technical sports was associated with increased odds of LBP for both sexes in the current study.

In the current study, participation in team sports was associated with increased odds of LEP. A study among Norwegian adolescent athletes found that 20% of handball players and 36% of volleyball players reported overuse knee problems.[8] In particular, patellofemoral pain is one of the most common complaints observed in adolescent athletes.[16] Patellar tendinopathy and Osgood-Schlatter syndrome are examples of overuse injuries shown to be of major concern for athletes in team sports that require a high volume of jumping and speed training and are especially frequent among volleyball players.[46]

Overuse injuries of the lower extremities are also commonly reported in sports requiring repetitive movements of the lower extremities such as track and field, with girls having higher injury rates than boys.[34,38] These results are consistent with the increased odds of LEP among girls who reported performing technical sports in this study. Reasons for higher susceptibility to overuse injuries and pain conditions in girls performing technical sports may include differences between sexes in anatomy, joint laxity, muscle strength, and neuromuscular and biomechanical factors, which affect physiological responses to excessive training loads and microtrauma.[38]

Concerning the interpretation of these results, it is important to emphasize that adolescents often participate in more than 1 type of sport. However, as the aim was to explore selective sport activities as potential contributing factors of musculoskeletal pain, we adjusted for participation in all other sports in order to minimize limitations related to overlapping sport exposures (and introduction of statistical dependency). Additionally, some participants reported pain in more than 1 body location, which should be considered when interpreting the results. However, sensitivity analyses of those reporting only NSP, LBP, or LEP confirmed the results from the main analyses. Identification of potential confounders and mediators was based on prior knowledge and assumed causal associations from results in previous studies. Anxiety and depression are strongly related to musculoskeletal pain,[19,23,33] and these health complaints may also increase the risk of inactivity due to low motivation for sport participation and social activities.[22] Unlike previous studies,[3,29] adjustment for symptoms of anxiety and depression was therefore conducted to reduce the overall bias in estimation of the relationship between PA/sports and musculoskeletal pain.

The knowledge gained through this study's identification of PA levels and sports associated with pain within the

various body locations creates the potential for prevention or earlier detection of musculoskeletal pain among adolescents. Based on our findings, it would seem that it is important for health care professionals who encounter active adolescents with pain to consider not only the general PA level (days of PA per week) but to identify types of sport participation as well. Sports found to be associated with a decreased likelihood of musculoskeletal pain could probably be recommended as part of primary preventive strategies. Furthermore, our results can provide coaches and health professionals with a better basis for understanding the potential risks associated with different sports, thus increasing their awareness and opportunities to guide and adapt athletic activity to prevent development of long-term pain conditions. Launay[25] emphasizes that young athletes must learn to listen to their bodies in order to be able to adapt, change, or stop painful exercise before overuse injuries become chronic. To assist active adolescents, one should be aware of the early signs of overuse and be prepared to raise questions about sport participation and the frequency and type of exercise.[25] However, to develop and implement guidelines for coaches, health professionals, and athletes, more longitudinal studies providing evidence about the causal relationships between different types of sport participation and various locations of musculoskeletal pain outcomes will be needed.

Nevertheless, one also needs to recognize that in most cases, long-lasting pain among adolescents is the result of multifactorial conditions, and several studies have demonstrated a strong association between mental health problems and NSP and LBP.[30,37] This is also a factor in LEP; for example, patellofemoral pain is one of the frequent complaints for which clinicians are strongly recommended to address potential psychosocial factors interacting with the patient's presentation of pain.[4] Clinical assessment of adolescents with pain complaints should therefore include both physical and psychological symptoms.[37] It is also important to balance the adverse health outcomes inherent in any type of sport with the risks associated with a more sedentary lifestyle. Sedentary behavior is found to be strongly associated with adverse health outcomes, including obesity, cardiovascular and metabolic diseases, psychological problems, antisocial behavior, and decreased academic achievement.[45] Hence, from a public health perspective, the numerous benefits of regular PA to physical, mental, and social health may outweigh the negative aspects of pain related to some types of sports in this study.

Taken together, our results suggest that strategies for prevention of musculoskeletal pain should include consideration of types of sport participation in addition to the overall level of PA, as well as the location of pain and sex differences. However, further studies on the impact of type and frequency of sport participation on musculoskeletal pain, as well as age and sex differences, will be necessary to develop targeted and effective prevention strategies for adolescents.

Study Strengths and Limitations

Strengths of this study are the large sample size and the information regarding pain location and frequency of pain, as well as the information about sport participation. Since previous findings on the relationship between PA and musculoskeletal pain have been inconsistent, the ability to investigate the association between various levels of PA and a range of sports activities and the 3 most common pain locations is the major strength of the study.

The cross-sectional design is the main limitation of this study as it prevented us from making valid causal inferences from these observational data. The outcome of pain was defined as musculoskeletal pain unrelated to any known disease or acute injury, restricted to pain reported at a frequency of $\geq$1 day per week during the past 3 months. A limitation, however, is the lack of specific information about pain severity. Nevertheless, a high number of pain-associated disabilities, including sleep problems and limitations in activities of daily living, have previously been found among adolescents reporting musculoskeletal pain with a frequency of at least once a week.[19,20] It should be noted that pain potentially caused by overuse-related injuries, typically characterized by a gradual and cumulative process of tissue damage without a single definable event associated with their onset,[8,13] was included in our case definition of musculoskeletal pain. The wording of the pain question in our questionnaire should minimize the possibility of reporting musculoskeletal pain resulting from acute injuries with a specific, clearly identifiable injury event. However, we cannot exclude the possibility that some of the adolescents might have misunderstood this question about pain. Furthermore, the outcome in this study was pain experienced during the previous 3 months, which might have introduced recall bias. It has, however, been shown that adolescents are able to accurately recall and report pain experienced during a 3-month period.[27]

Both exposure and outcome variables were self-reported, making them susceptible to information bias. Even though self-reports of PA have been criticized, the questions used in this study have been shown to provide reliable and valid measurements for physical fitness.[35]

CONCLUSION

In a large population-based sample of adolescents, we found that PA at a moderate level was associated with reduced likelihood of NSP and LBP and that endurance sports may be particularly beneficial. Participation in technical sports was associated with increased odds of LBP, whereas participation in team sports was associated with increased odds of LEP. Our findings highlight the need for health care professionals to consider the types of sports adolescents participate in and not only their overall level of PA when evaluating their musculoskeletal pain.

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APPENDIX

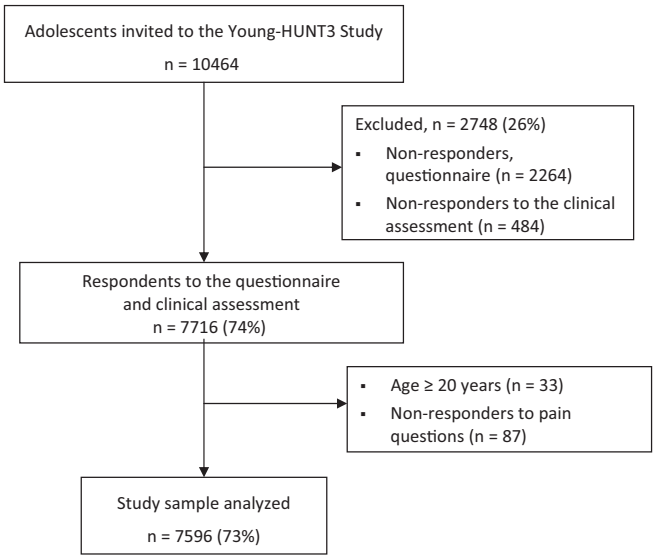

Figure A1. Flowchart of the study sample.

TABLE A1
Odds of Persistent Weekly Pain Related to Level of Physical Activity, Crude Analyses, and Analyses Adjusted for Age, Socioeconomic Status, and Psychological Distress[a]

	OR [95% CI] for Persistent Weekly Pain[b]		OR [95% CI] for Persistent Weekly Pain[b]	
	Crude	Adjusted[c]	Crude	Adjusted[c]
	NSP—Girls		NSP—Boys	
Low PA (≥1 d/wk)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Moderate PA (2-3 d/wk)	**0.66 [0.54-0.80]**	**0.79 [0.63-0.99]**	**0.73 [0.56-0.95]**	**0.74 [0.55-1.00]**
High PA (≥4 d/wk)	**0.60 [0.49-0.74]**	0.84 [0.67-1.06]	**0.72 [0.56-0.92]**	0.80 [0.61-1.06]
	LBP—Girls		LBP—Boys	
Low PA (≥1 d/wk)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Moderate PA (2-3 d/wk)	**0.66 [0.53-0.82]**	**0.77 [0.60-0.98]**	**0.66 [0.50-0.88]**	**0.70 [0.51-0.95]**
High PA (≥4 d/wk)	**0.69 [0.55-0.86]**	0.94 [0.73-1.20]	0.81 [0.63-1.04]	0.92 [0.70-1.21]
	LEP—Girls		LEP—Boys	
Low PA (≥1 d/wk)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
Moderate PA (2-3 d/wk)	0.89 [0.68-1.16]	0.99 [0.75-1.33]	1.38 [0.97-1.96]	1.48 [1.00-2.18]
High PA (≥4 d/wk)	1.22 [0.95-1.57]	**1.39 [1.05-1.85]**	**1.93 [1.40-2.66]**	**2.06 [1.44-2.95]**

[a]Values in boldface indicate statistically significant associations ($P < .05$). LBP, low back pain; LEP, lower extremity pain; NSP, neck and shoulder pain; OR, odds ratio.
[b]Reported pain ≥1 d/wk the previous 3 months.
[c]Adjusted for age, socioeconomic status, and psychological distress.