JYX
JYVÄSKYLÄN YLIOPISTO
UNIVERSITY OF JYVÄSKYLÄ

This is a self-archived version of an original article. This version may differ from the original in pagination and typographic details.

Author(s): Pirnes, Katariina Pauliina; Kallio, Jouni; Kankaanpää, Anna; Häkkinen, Arja; Tammelin, Tuija

Title: Associations of neck and shoulder pain with objectively measured physical activity and sedentary time among school-aged children

Year: 2020

Version: Accepted version (Final draft)

Copyright: © 2020 Walter de Gruyter GmbH

Rights: In Copyright

Rights url: http://rightsstatements.org/page/InC/1.0/?language=en

Please cite the original version:

Pirnes, K. P., Kallio, J., Kankaanpää, A., Häkkinen, A., & Tammelin, T. (2020). Associations of neck and shoulder pain with objectively measured physical activity and sedentary time among school-aged children. Scandinavian Journal of Pain, 20(4), 821-827. https://doi.org/10.1515/sjpain-2020-0038

Associations of neck and shoulder pain with objectively measured physical activity and sedentary time among school-aged children

ABSTRACT

BACKGROUND AND AIMS: The potential effects of physical activity and sedentary time on children's increasing neck and shoulder pain are unclear. The aim of this cross-sectional study was to evaluate the associations between objectively measured physical activity or sedentary time and neck and shoulder pain in children.

METHODS: Children (n=905; 10-15 years old) filled in an electronic questionnaire during school hours on the frequency of their neck and shoulder pain. Daytime moderate to vigorous physical activity and sedentary time were measured objectively with an ActiGraph accelerometer. A multinomial logistic regression was applied to study the associations. The results were adjusted for age, gender, body mass index and bedtime.

RESULTS: Neck and shoulder pain experienced at least once a week was reported by 26.1% of children. A higher proportion of boys (45.9%) than girls (24.2%) achieved at least 60 minutes of moderate to vigorous physical activity/day ($p<0.001$). Girls were more sedentary than boys (sedentary time 66.4% vs. 63.1%) ($p<0.001$). Higher moderate to vigorous physical activity time was associated with a lower probability of experiencing neck and shoulder pain among boys, but not among girls. No association was found between sedentary time and neck and shoulder pain.

CONCLUSIONS: A quarter of the girls and boys reported frequent neck and shoulder pain. Boys achieved more moderate to vigorous physical activity than girls and higher moderate to vigorous physical activity was associated with a lower probability of having neck and shoulder pain, but only in boys.

IMPLICATIONS: Neck and shoulder pain is the most common musculoskeletal pain and its prevalence is increasing. Preventing childhood pain is important, as neck and shoulder pain causes restrictions in daily living and is persistent to adulthood. Our study showed, that boys with more moderate to vigorous physical activity, had less weekly neck and shoulder pain symptoms. The

present results are an addition to the list of benefits of physical activity and are valuable to, for example, healthcare personnel and teachers, who guide and teach children and adolescents. Families can benefit from new knowledge when considering supportive parenting activities. Municipalities can use the new information to design services for children or families.

Keywords: Exercise, sedentary behavior, pain, accelerometry, child

BACKGROUND

Neck and shoulder pain (NSP) can occur already in childhood. Children experience pain most commonly in the neck and shoulder area (8, 22) and about 15–32% of children report experiencing NSP at least once a week (11, 22, 23, 38). In addition, increases have been reported in pain rates in children and in the lifetime pain prevalence of pain (11, 16, 22, 32, 35) and in the prevalence of self-reported restrictions caused by pain (29).

A link between NSP and physical activity (PA) or sedentary time (ST) has also been proposed as their relevance is commonly recognized in promoting health among youth (15, 34). However, studies on the associations of PA or ST with pain alone have yielded conflicting findings. Cross-sectional studies, in which PA has been measured with a questionnaire, have generally found no association between PA and NSP among school-aged children (7, 19) or adolescents (27). One study, however, reported that high-level PA tends to be associated with a higher prevalence of neck pain in 15- to 16-year-old girls (3). Research on the associations between objectively measured PA and NSP in school-aged children is particularly scarce. The associations of pain with objectively measured PA have been explored in only a few cohort studies (1, 26, 39). None of these reported separately on NSP.

Another factor underlying children's NSP may be the amount of time spent sedentary. According to the Finnish recommendations, school-aged children should engage in moderate to vigorous physical activity (MVPA) for at least one hour per day and avoid excessive ST (25). The amount of MVPA tends to decrease from childhood to young adulthood and that of ST tends to increase (14, 26, 32, 39). In a questionnaire study conducted in Brazil, adolescents who reported more inactive choices in their everyday life, were approximately 50% more likely to have neck pain (30). Sedentary

activities such as watching television and reading books were associated with neck, shoulder or occipital pain in girls whereas playing or working with a computer was associated with neck or occipital pain in boys (3). A recent Finnish study on NSP showed that a higher amount of objectively measured ST was associated with a 13% higher prevalence of NSP at least once a week among children who engaged in less than 60 minutes of MVPA per day (31).

Information on the role of PA and ST and the presence of childhood NSP is both limited and conflicting, and calls for more research. Thus, the aim of this study was to investigate the possible associations between NSP and objectively measured PA and ST in 10- to 15-year-old school-aged children.

METHODS

Participants

In total, 970 children from nine schools in different parts of Finland were invited to participate in the study. A questionnaire was filled in by 947 of these children. After excluding children who reported NSP due to spinal injuries, the final sample of this cross-sectional study comprised 905 10- to 15-year- old children (mean 12.5 years$\pm$ 1.3 years; 52.5% girls). Of this number, 684 (75.6%) provided information on all the study variables. In accordance with the Declaration of Helsinki, a written informed consent was obtained from all the children and their guardians before participation in the study. The study setting was approved by the Ethics committee of the University of Jyväskylä (January 2012).

Instrument and procedure

In 2015, as part of the research related to the national “Finnish Schools on the move” program (17, 18, 36), the present participants filled in an electronic questionnaire during school hours in which they rated their experience of NSP. They were asked the question: “How often have you had symptoms in the last three months”? The question was followed by a list of body areas, such as “neck or shoulder pain or ache” and five answer options: 1) almost daily, 2) more than once a week, 3) about once a week, 4) once a month, and 5) rare or never. The questionnaire included a picture of the human body with named zones to ensure that the relevant regions of the body were understood correctly. Participants could seek with the questionnaire from an adult in the classroom. For the analysis, the prevalence of NSP was recoded into three categories; rare or never, about once a month and at least once a week.

Participants were also asked to report if the pain originated from a trauma: “Have you injured any of the above-mentioned and pictured pain areas during the last three months (for example as result of falling, stumbling, breaching while doing sports, etc.)?” Response options were “yes” or “no.” If the answer was “yes,” they were asked to mark the injured body area on the menu with the help of the body map. Children (n=42) with pain due to trauma in the spinal area were excluded from the analysis.

Accelerometers are movement sensors that are feasible to be used in large scale studies and capable of measuring time spent unmoved or at different PA intensities (20). In the current study, daytime PA and ST were assessed with a hip-worn ActiGraph triaxial GT3X+ and wGT3X+ accelerometers (ActiGraph, Pensacola, Florida, USA). Participants were instructed to wear the monitor on the right hip during waking hours for seven full consecutive days, except while bathing or doing other water-based activities. Applying Actilife software (version 6.11.7), data were collected in raw 30 Hz acceleration, downloaded and converted to counts 15-second epochs. A customized Visual Basic

macro for Excel software was used for data reduction. Readings of ≥500 min/day on three days (two valid weekdays and one weekend day) or more time measured between 7:00 and 23:00 were required for a valid monitoring period (4). Periods of consecutive zero counts lasting 30 min were defined as non-wear time (5). Over 20 000 counts per minute (cpm) data were excluded as spurious accelerations (12). The cut-points proposed by Evenson et al. (2008) were used to calculate MVPA (≥2296 cpm) and ST (≤100 cpm) (9). Accelerometer-based sedentary time was expressed as a percentage of daily wear time. MVPA and ST were calculated as weighted averages of weekday and weekend day averages (Total PA = [5 * average weekday PA + 2 * average weekend day PA]/7).

Each participant's weight and height were measured and used to calculate the body mass index (BMI). A SECA 877 was used to measure body weight. Weight was measured twice to the nearest 0.1 kg. If the results between measurements differed by more than 0.2 kg, a third measurement was made. The average of the two closest results was recorded in the measurement protocol. Height was measured with a portable Charder HM 200P measuring instrument. The measurement was performed twice. If the results between the measurements differed by more than 0.4 cm, a third measurement was made. The average of the two closest results was recorded in the measurement protocol. Bedtime was determined by the question "What time do you usually go to bed if you have to go to the school next morning"? The answer was selected from a list of times specified in half hour intervals.

Data analysis

Descriptive statistics were calculated by using SPSS 20.0 for Windows (SPSS Inc., Chicago, IL), and all further analyses were conducted using Mplus statistical package (Version 7). The descriptive statistics are presented as means and standard deviations or percentages (%).

Differences in study variables were tested using Student`s t-test or Pearson`s chi-squared test. To study the association between objectively measured PA (MVPA) and ST on the prevalence of pain in the neck and shoulders, multinomial logistic regression analysis was conducted. In the analysis, the prevalence of NSP was treated as dependent variable and objectively measured MVPA/ST as an independent variable. Groups who had a) NSP at least once a week b) NSP about once a month were compared to the group c) NSP experienced rarely or never that was used as a reference category in the modeling. To examine whether the associations differed by gender and age, interaction terms were tested for significance (three-way interaction gender × age × MVPA/ST, and all the lower order terms were included in the model). In addition, the model was adjusted for BMI, bedtime and injuries (1=traumatic pain in spinal area, 0= no traumatic pain in spinal area). When a significant interaction was observed, simple slopes for the association between MVPA/ST and NSP were examined.

The unequal probabilities of selection (by age and gender) were accounted for the modeling by using sampling weights. The sampling weights were constructed by using information on the general population structure obtained from Official Statistics of Finland (24). Model parameters were estimated by using the full information maximum likelihood method with robust standard errors (MLR). The method produces the estimates of the standard errors that are robust to non-normality. Missing data were assumed to be missing at random (MAR). Because data were clustered within schools and school classes, standard errors were calculated by using a special feature of Mplus (TYPE=COMPLEX).

RESULTS

No differences were observed in the prevalence of NSP (p=0.271) or in the level of ST (p=0.227) between participants with (n=684) and without complete data (n=905). However, participants with incomplete data were more often boys (58.8% vs. 43.9%, p<0.001), were older (mean 12.9 years vs. 12.4 years, p<0.001), had a higher BMI (mean 19.3 vs. 18.7, p=0.020), a later bedtime (mean 3.4 vs. 2.9, p<0.001) and a higher level of PA (mean MVPA 60.5 min/day vs. 52.3 min/day, p=0.025).

NSP was experienced at least once a week by 26.1%, and once a month by 32.3% of the 905 children. No gender difference was found in the prevalence of NSP. The PA recommendations were met by 33.8% of the children. A higher proportion of boys (45.9%) than girls (24.2%) reported meeting the recommended 60 min of daily MVPA (p<0.001). On average, 64.9% of the wearing time was ST. Girls were more sedentary (66.4%/day) than boys (63.1 %/day) (p<0.001).

Association between MVPA and NSP

The association between MVPA and NSP experienced at least once a week differed by gender (p = 0.020) (Table 2). Higher MVPA time was associated with a lower probability of experiencing NSP at least once a week among boys, but not among girls (boys, p = 0.031 and girls, p = 0.230; Figure 1). Among boys, the odds ratios for weekly NSP symptoms were 1.5% lower per one minute more of MVPA (OR=0.99; 95% CI). For example, boys with 30 minutes more MVPA had 36% lower odds for experiencing weekly NSP symptoms (OR=0.64; 95% CI). MVPA was not associated with NSP experienced once a month. Because the regression coefficient for the three-way interaction term gender x age x MVPA was not significant in the model of NSP (symptoms experienced at least once a week: b = -0.005, se = 0.008, p = 0.538 and once a month: b = -0.003, se = 0.007, p = 0.710) the term was not included in the final model.

Association between sedentary time and NSP

ST was not associated with NSP symptoms experienced at least once a week (Table 3). The three-way interaction term gender × age × sedentary time was not significant in the model of NSP (symptoms experienced at least once a week: $b = 0.010$, $se = 0.028$, $p = 0.361$ and once a month: $b = -0.010$, $se = 0.020$, $p = 0.622$) and hence was not included in the final model.

DISCUSSION

To our knowledge, this study is among the first to evaluate the association between objectively measured PA, ST and NSP in children. The main finding was, that boys who engaged more in MVPA had a lower prevalence of weekly NSP, while no such association was found among girls. Boys with 30 minutes or more MVPA per day had a 36% lower likelihood of experiencing weekly NSP symptoms than boys with less than 30 minutes of MVPA per day. ST was not associated with NSP in either in boys or girls in this study.

The present study supports earlier findings that children experience NSP rather often (6, 7, 32, 35, 37) and that their mean levels of PA are relatively low (12, 37). Weekly NSP symptoms were reported by more than a quarter of the children. This is even more than reported by Husu et al. (2016) for a sample of 10- to 14-year-old children: NSP was experienced at least weekly by 7.3% of boys and in 14.0 % of girls (14). In our study, the number of children with MVPA below the recommended 60 minutes daily was 66% and thus rather high. Only 24% of girls compared to 46% of boys attained the recommended amount of MVPA. Similar results were obtained in other recent Finnish studies, where on average one-third of participants met the PA guidelines (13, 14). One study (13) found a gender gap similar the one observed in our study, in meeting the recommended level physical activity.

In our study, the boys with more MVPA seemed to experience less self-reported NSP. An association between PA intensity and neck, mid-back or lower back pain in 6- to 12-year-old children (n=1205) was found by Franz et al. in their longitudinal study (10). Shifting from sedentary to moderate intensity activities tended to protect against spinal pain. On the other hand, shifting from time spent in sedentary activities to vigorous physical activities was associated with increased occurrences of spinal pain (10). In a Norwegian study, the most active boys (mean 17.5 years) reported higher sum scores for neck, shoulder and upper back pain during the previous four weeks than less active counterparts (27). The discrepancy in the results of these studies may be explained by age and the method used to measure PA intensity.

To our knowledge, the current finding that higher level of objectively measured MVPA is associated with lower probability of having NSP among boys has not been reported before. For girls, other factors may be more dominant than PA in the prevention of NSP. For example, symptoms of depression are associated with increased risk of NSP in both genders (7, 23, 33, 35, 38), and especially for girls, according to a study of Pollock et al. 2011 including 1258 14-year old girls and boys (28).

Only a few studies have investigated ST and its associations with pain in children. In their cross-sectional study, Siekkinen et al. (2016) found, that an increase of one percent in objectively measured ST (mean eight minutes) was associated with a 13% higher prevalence of NSP experienced at least once a week among children who engaged in less than 60 minutes of MVPA per day (68.5%) (31). Another cross-sectional study reported that both prolonged sitting and a high level of physical activity seem to be related to neck or occipital pain among adolescents (3). However, in the current study, no association was observed between NSP and ST in children.

The strength of this study was the utilization of objective measurements of PA and ST with high monitor wearing time. Objective measures are considered a more reliable method than self-reports, especially in the case of children (2, 21). To increase the reliability of the study, the analysis was restricted to children with at least 500min/day of accelerometer-wearing time (two valid weekdays and one weekend day). This enabled us to gain a better picture of the actual activity of children. No differences were observed in the prevalence of NSP or level of ST between the participants with and those without complete data (data not shown).

It is possible that PA was underestimated in the study, as accelerometers could not be used in water-related PA. Moreover, acceleration cannot be measured reliably during cycling. This leaves some categories of PA out of the MVPA analyzed in this study. Further, the cross-sectional study design does not allow causal conclusions to be drawn.

The results of this study partially support earlier findings that moderate intensity PA may protect against the development of pain in children (10, 39). Because higher MVPA was only associated with a lower prevalence of NSP among boys, the results support the current recommendation for health-related PA in boys (25). More research is needed on what or what kind of PA would be associated with lower NSP on girls.

CONCLUSION

The results of this study indicate that NSP is common among school children. Boys who engaged in more MVPA had a lower prevalence of weekly NSP; however, no such association was found among girls. In conclusion, we would encourage boys who suffer from NSP or whose amount of PA is less than recommended 60 minutes of PA per day to increase their MVPA.

IMPLICATIONS

NSP is the most common musculoskeletal pain and its prevalence is increasing. Preventing childhood NSP is important, as NSP causes restrictions in daily living and is persistent to adulthood. Our study showed, that boys with more MVPA, had less weekly NSP symptoms. The present results are an addition to the list of benefits of PA and are valuable to, for example, healthcare personnel and teachers, who guide and teach children and adolescents. Families can benefit from new knowledge when considering supportive parenting activities. Municipalities can use the new information to design services for children or families.

Authors' statements

Research funding: This study was funded by the Finnish Ministry of Education and Culture and the Juho Vainio Foundation.

Conflict of interest: Authors state no conflict of interest.

Informed consent: Informed consent has been obtained from all individuals included in this study.

Ethical approval: The study setting for the measurements in 2013–2015 was approved by the Ethics Committee of the University of Jyväskylä. Participants and their parents signed written informed consent forms before they participated in this study. All measurements were carried out in accordance with the Declaration of Helsinki. Participation was voluntary and could be discontinued at any point during the research.

REFERENCES

1. Aartun E, Hartvigsen J, Boyle E, Hestbaek L. No association between objectively measured physical activity and spinal pain in 11-15-year-old Danes. European Journal of Pain 2016;20(3): 447–457.
2. Adamo KB, Prince SA, Tricco AC, Connor-Gorber S, Tremblay M. A comparison of indirect versus direct measures for assessing physical activity in the pediatric population: A systematic review. International Journal of Pediatric Obesity 2009;4:2–27.
3. Auvinen J, Tammelin T, Taimela S, Zitting P, Karppinen J. Neck and shoulder pains in relation to physical activity and sedentary activities in adolescence. Spine 2007;32: 1038–1044.
4. Cooper AR, Goodman A, Page AS, Sherar LB, Esliger DW, van Sluijs EM, Andersen LB, Anderssen S, Cardon G, Davey R, Froberg K, Hallal P, Janz KF, Kordas K, Kreimler S, Pate RR, Puder JJ, Reilly JJ, Salmon J, Sardinha LB et al. Objectively measured physical activity and sedentary time in youth: The International children's accelerometry database (ICAD). International Journal of Behavioral Nutrition and Physical Activity 2015;12(1):113.
5. Domazet SL, Tarp J, Huang T, Gejl AK, Andersen LB, Froberg K, Bugge A. Associations of Physical Activity, Sports Participation and Active Commuting on Mathematic Performance and Inhibitory Control in Adolescents. PLoS ONE 2016;11(1):e0146319. doi.org/10.1371/journal.pone.0146319.
6. Dianat I, Alipour A and Asgari Jafarabadi M. Risk factors for neck and shoulder pain among schoolchildren and adolescents. J Paediatr Child Health 2018;54: 20–27. doi:10.1111/jpc.13657.
7. Diepenmaat ACM, van der Wal MF, de Vet HCW, Hirasing RA. Neck/shoulder, low back and arm pain in relation to computer use, physical activity, stress and depression among Dutch adolescents. Pediatrics 2006;117:412–416.

8. El-Metwally A, Salminen JJ, Auvinen A, Kautiainen H, Mikkelsson M. Prognosis of non-specific musculoskeletal pain in preadolescents: a prospective 4-year follow-up study till adolescence. Pain 2004;110:550–559.
9. Evenson KR, Catellier DJ, Gill K, Ondrak KS, McMurray RG. Calibration of two objective measures of physical activity for children. Journal of Sports Sciences 2008;26(14):1557–1565. doi:10.1080/02640410802334196.
10. Franz C, Møller NC, Korsholm L, Jespersen E, Hebert JJ, Wedderkopp N. Physical activity is prospectively associated with spinal pain in children (CHAMPS Study-DK). Scientific Reports 2017;7. Article number:11598. doi:10.1038/s41598-017-11762–4.
11. Hakala P, Rimpelä A, Salminen JJ, Virtanen SM, Rimpelä M. Back, neck, and shoulder pain in Finnish adolescents: national cross sectional surveys. BMJ 2002;325:743.
12. Heil DP, Brage S, Rothney MP. Modeling physical activity outcomes from wearable monitors. Medicine & Science in Sports & Exercise 2012;44(1S):50–60. doi:10.1249/MSS.0b013e3182399dcc.
13. Husu P, Jussila A-M, Tokola K, Vähä-Ypyä H, Vasankari T. Objektiivisesti mitattu paikallaanolo ja liikkuminen. Teoksessa S. Kokko & A. Mehtälä (toim.) Lasten ja nuorten liikuntakäyttäytyminen Suomessa. LIITU- tutkimuksen tuloksia 2016. Valtion liikuntaneuvoston julkaisuja 2016;4:16–22.
14. Husu P, Vähä-Ypyä H, Vasankari T. Objectively measured sedentary behavior and physical activity of Finnish 7- to 14-year-old children–associations with perceived health status: a cross-sectional study. BMC Public Health 2016;16:338. doi:10.1186/s12889-016-3006-0.
15. Janssen I, Leblanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. Int J Behav Nutr Phys Act 2010;7:40. doi:10.1186/1479-5868-7-40.
16. Jeffries LJ, Milanese SF, Grimmer-Somers KA. Epidemiology of adolescent spinal pain: A

systematic overview of the research literature. Spine 2007;32:2630–2637.

17. Joensuu L, Syväoja H, Kallio J, Kulmala J, Kujala UM, Tammelin TH. Objectively measured physical activity, body composition and physical fitness: Cross-sectional associations in 9- to 15-year-old children. Eur J Sport Sci 2018;18(6):882–892. doi:10.1080/17461391.2018.1457081.
18. Kallio J, Hakonen H, Syväoja H, Kulmala J, Kankaanpää A, Ekelund U, Tammelin T. Changes in physical activity and sedentary time during adolescence – gender differences during weekdays and weekend days. Scand J Med Sci Sports 2020;00:1–11. doi.org/10.1111/sms.13668.
19. Kujala UM, Taimela S, Viljanen T. Leisure physical activity and various pain symptoms among adolescents. Br J Sports Med 1999;33:325–328.
20. Lee I, Shiroma EJ. Using accelerometers to measure physical activity in large-scale epidemiological studies: issues and challenges. British Journal of Sports Medicine 2014;48:197–201.
21. Lubans DR, Hesketh K, Cliff DP, Barnett LM, Salmon J, Dollman J, Morgan PJ, Hills AP, Hardy LL. A systematic review of the validity and reliability of sedentary behaviour measures used with children and adolescents. Obes Rev 2011;12:781–799.
22. Mikkelsson M, Salminen J, Kautiainen H. Non-specific musculoskeletal pain in preadolescents. Prevalence and 1-year persistence. Pain 1997;73(1):29–35.
23. Myrtveit SM, Sivertsen B, Skogen JC, Frostholm L, Stormark KM, Hysing M. Adolescent neck and shoulder pain–the association with depression, physical activity, screen-based activities, and use of health care services. J Adolesc Health 2014;55:366–372.
24. Official Statistics of Finland (OSF): Population structure [e-publication]. ISSN=1797-5395. Helsinki: Statistics Finland [referred: 13.6.2017]. Access method: http://www.stat.fi/til/vaerak/tau_en.html

25. Opetusministeriö ja Nuori Suomi 2008. Fyysisen aktiivisuuden suositus kouluikäisille 7–18-vuotiaille. Helsinki: Opetusministeriö ja Nuori Suomi ry.
26. Ortega FB, Konstabel K, Pasquali E, Ruiz JR, Hurtig-Wennlöf A, Mäestu J, Löf M, Harro J, Bellocco R, Labayen I, Veidebaum T, Sjöström M. Objectively measured physical activity and sedentary time during childhood, adolescence and young adulthood: A cohort study. PloS ONE 2013;8(4):e60871.
27. Østerås N, Ljunggren AE, Gould KS, Wærsted M, Veiersted KB. Muscle pain, physical activity, self-efficacy and relaxation ability in adolescents. Adv Physiother 2006;8:33–40.
28. Pollock CM, Harries RL, Smith AJ, Straker LM, Kendall GE, O'Sullivan PB. Neck/shoulder pain is more strongly related to depressed mood in adolescent girls than in boys. Manual Therapy 2011;16:246–251.
29. Roth-Isigkeit A, Thyen U, Stoven H, Schwarzenberger J, Schmucker P. Pain Among Children and Adolescents: Restrictions in Daily Living and Triggering Factors. Pediatrics 2005;115(2):152–162.
30. Scarabottolo, CC, Pinto, RZ, Oliveira, CB, Zanuto E, Cardoso J, Christofaro D. Back and neck pain prevalence and their association with physical inactivity domains in adolescents. Eur Spine J 2017;26:2274. doi-org.ezproxy.jyu.fi/10.1007/s00586-017-5144-1.
31. Siekkinen K, Kankaanpää A, Kulmala J, Tammelin T. Association of objectively measured sedentary time and neck-shoulder pain in 10- to 12-year-old children. Liikunta & Tiede 2016;53(1):54–59.
32. Siivola SM, Levoska S, Latvala K, Hoskio E, Vanharanta H, Keinänen-Kiukaanniemi S. Predictive factors for neck and shoulder pain: a longitudinal study in young adults. Spine 2004;29:1662–1669.
33. Stallknecht SE, Strandberg-Larsen K, Hestbæk L, Nybo Andersen A-M. Spinal pain and co-occurrence with stress and general well-being among young adolescents: a study within the

Danish National Birth Cohort. Eur J Pediatr 2017;176:807–814. doi-org.ezproxy.jyu.fi/10.1007/s00431-017-2915-y.

34. Straker L, Howie EK, Cliff DP, Davern MT, Engelen L, Gomersall SR, Ziviani J, Schranz NK, Olds T, Tomkinson GR. Australia and Other Nations Are Failing to Meet Sedentary Behaviour Guidelines for Children: Implications and a Way Forward. J Phys Act Health 2016;13(2):177–88. doi:10.1123/jpah.2015-0026.
35. Ståhl M, Kautiainen H, El-Metwally A, Häkkinen A, Ylinen J, Salminen JJ, Mikkelsson M. Non-specific neck pain in schoolchildren: Prognosis and risk factors for occurrence and persistence. A 4-year follow-up study. Pain 2008;137:316–22.
36. Syväoja HJ, Kankaanpää A, Joensuu L, Kallio J, Hakonen H, Hillman CH, Tammelin TH. The Longitudinal Associations of Fitness and Motor Skills with Academic Achievement. Med Sci Sports Exerc 2019;51(10):2050–2057. doi:10.1249/MSS.0000000000002031.
37. Tammelin T, Laine K, Turpeinen S. Physical Activity of School-aged children. Abstract in English. LIKES – Research Reports on Sport and Health 272. Jyväskylä: LIKES – Foundation for Sport and Health Science; 2013.
38. Vikat A, Rimpelä M, Salminen J, Rimpelä A, Savolainen A, Virtanen S. Neck and shoulder pain and low back pain in Finnish adolescents. Scandinavian Journal of Public Health 2000;28(3):164–173.
39. Wedderkopp N, Kjaer P, Hestbaek L, Korsholm L, Leboeuf-Yde C. High-level physical activity in childhood seems to protect against low back pain in early adolescence. Spine J 2009;9:134–141.

Table 1. Study variables for boys and girls combined and separately.

	All	Girls	Boys	
	n=905	n=475	n=430	*p* [1]
Age, years				
mean (SD)	12.5 (1.3)	12.5 (1.3)	12.5 (1.2)	0.844
BMI	n=852			
mean (SD)	18.8 (3.2)	19.0 (3.2)	18.6 (3.3)	0.038
Accelerometer measurements	n=721			
MVPA (min/day), mean (SD)	52.7 (21.7)	47.7 (18.5)	59.1 (23.8)	<0.001
< 60min/day, %	66.2	75.8	54.1	
≥ 60min/day, %	33.8	24.2	45.9	<0.001
Sedentary time (%/day), mean (SD)	64.9 (7.5)	66.4 (7.0)	63.1 (7.6)	<0.001
Wearing time (min/day), mean (SD)	770 (54)	773 (52)	765 (56)	<0.001

Survey measurements	n=905			
NSP, %				
Never	41.7	40.4	43.0	
About once a month	32.3	31.2	33.5	
At least once a week	26.1	28.4	23.5	0.240
Bedtime, range 1-7				
mean (SD)	3.0 (1.4)	3.0 (1.4)	3.0 (1.4)	0.680

Attention: BMI= Body mass index, NSP= Neck and shoulder pain, MVPA= Moderate to vigorous physical activity. Bedtime answer options: 1 = No later than 21:00; 2 = 21:30; 3 = 22:00; 4 = 22:30; 5 = 23:00; 6 = 23:30; 7 = 24:00 or later. [1] *p*-value for gender difference (Student's t-test or Pearson's chi-squared test).

Table 2. Association between moderate to vigorous physical activity (MVPA) and neck and shoulder pain. Results of multinomial logistic regression analyses.

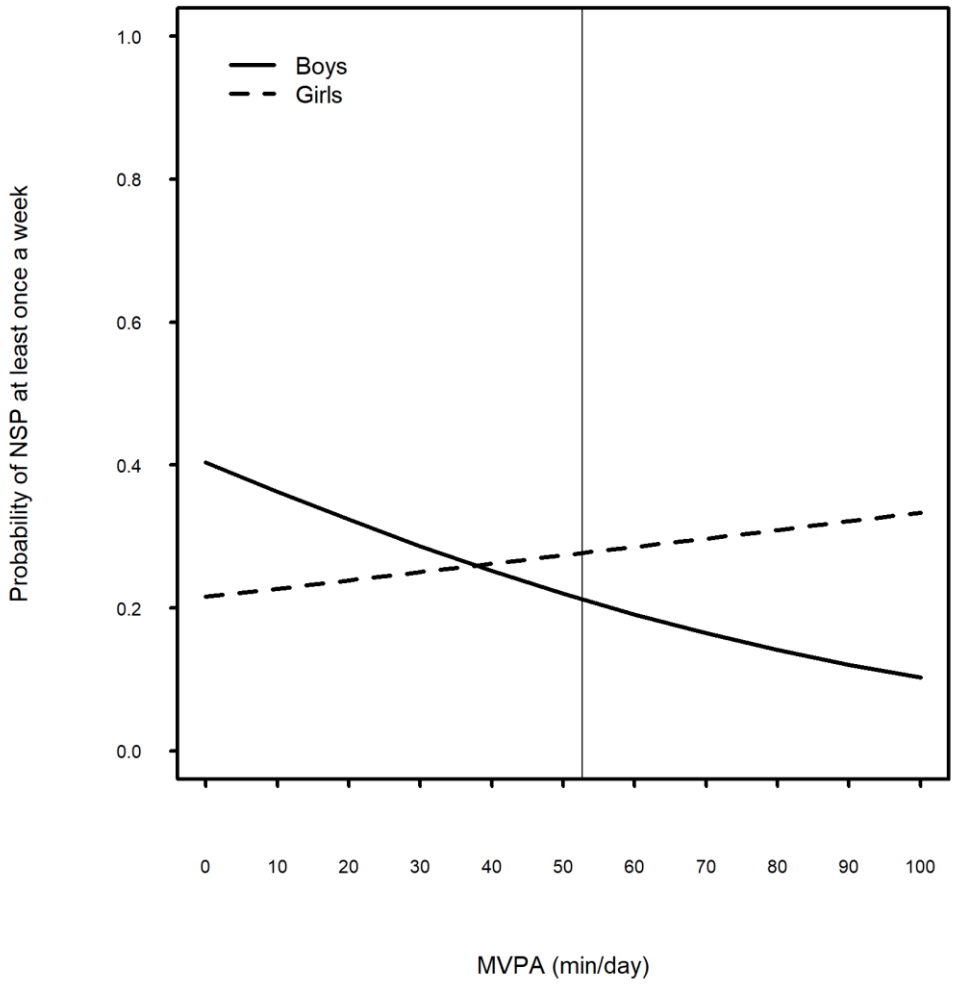
	Once a month vs. rare or never			At least once a week vs. rare or never		
	b	se	*P*	*b*	se	*P*
MVPA	0.007	0.005	0.214	-0.015	0.007	0.031
Gender *	0.163	0.195	0.403	0.421	0.185	0.023
Age	0.284	0.101	0.005	0.198	0.119	0.096
Body mass index	-0.057	0.027	0.037	0.007	0.031	0.821
Bedtime	0.114	0.078	0.143	0.249	0.095	0.009
Gender × MVPA	0.000	0.009	0.963	0.024	0.010	0.020
Age × MVPA	-0.005	0.004	0.123	0.003	0.004	0.484
Gender × Age	-0.198	0.124	0.110	0.014	0.142	0.923

b, unstandardized regression coefficient; se, standard error. *0=boy, 1=girl.

Table 3. Association between sedentary time (ST) and neck and shoulder pain. Results of multinomial logistic regression analyses.

	Once a month vs. rare or never			At least once a week vs. rare or never		
	b	se	*P*	*b*	se	*P*
ST	-0.026	0.019	0.176	0.031	0.024	0.197
Gender*	0.074	0.191	0.701	0.424	0.179	0.018
Age	0.314	0.113	0.005	0.154	0.127	0.223
Body mass index	-0.069	0.027	0.009	0.016	0.031	0.594
Bed time	0.119	0.077	0.125	0.238	0.094	0.012
Gender × ST	0.051	0.026	0.049	-0.031	0.035	0.384
Age × ST	0.010	0.010	0.287	-0.013	0.012	0.267
Gender × Age	-0.307	0.138	0.026	0.046	0.158	0.772

b, unstandardized regression coefficient; se, standard error. *0=boy, 1=girl.

Figure 1. Interaction between gender and moderate to vigorous physical activity (MVPA) on probability of neck and shoulder pain (NSP) experienced at least once a week.

Note. The predicted probabilities were calculated based on the parameters of the multinomial logistic regression model. NSP "rare or never" was treated as the reference category. The model was controlled for age, body mass index, bed time and injuries in the spinal area. Vertical line indicates the mean level of MVPA.