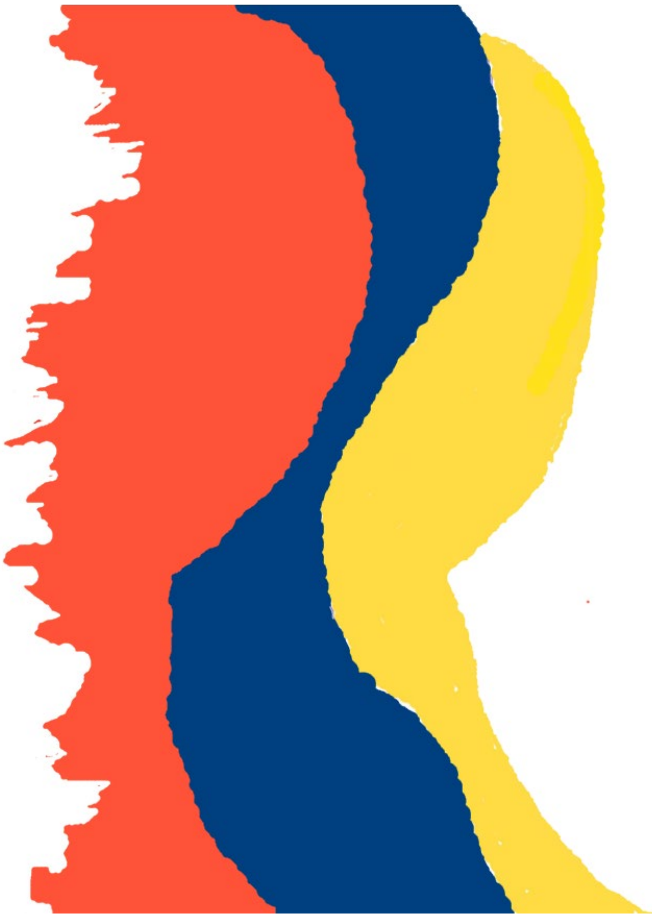
JYU DISSERTATIONS 619

Katariina Pirnes

Neck and Shoulder Pain in School-Aged Children with Special Reference to Physical Activity, Sedentary Time, and Physical Fitness Characteristics



UNIVERSITY OF JYVÄSKYLÄ
FACULTY OF SPORT AND HEALTH SCIENCES

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"Do not tell them how to do it. Show them how to do it and do not say a word. If you tell them, they will watch your lips move. If you show them, they will want to do it themselves."

Maria Montessori

ABSTRACT

Pirnes, Katariina Pauliina
Neck and shoulder pain in school-aged children with special reference to physical activity, sedentary time, and physical fitness characteristics
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This dissertation consists of four original papers in which the associations of NSP prevalence and incidence to moderate-to-vigorous physical activity (MVPA), sedentary time (ST), screen time, and physical fitness characteristics in 10- to 15-year-old school-aged children have been assessed.

First, the repeatability of the web-based pain questionnaire for school-aged children (N=206) was studied. A 2-year follow-up was conducted to study associations to children's (N=970) self-reported NSP: 1) cross-sectional data on accelerometer-measured MVPA and ST, 2) longitudinal data on accelerometer - measurements and information on self-reported physically passive screen time at three annual measurement points, and 3) Move! monitoring system physical fitness measurements in baseline and at 1-year measurement point.

The main findings were, that the questionnaire was a reliable method for detecting NSP in children. More than a quarter of the children reported suffering from weekly NSP, and the pain incidence was 15% and 18% during the first and second follow-up years. Boys who accumulated 30 min or more of accelerometer-measured MVPA per day had a 36% lower likelihood of weekly NSP incidence than less active ones. ST or MVPA was not associated with NSP at follow-up; however, self-reported screen time, especially physically passive gaming, and social media time was associated with the NSP incidence during the first, but not the second follow-up year. One additional screen time hour per day quadrupled the NSP incidence risk. Good physical fitness characteristics did not consistently predict the lower NSP incidence in school-aged children.

In conclusion, physically passive screen time is a health risk for the neck–shoulder region, and actions regarding pain risks in growth environments are needed. MVPA has positive effects, at least on boys' NSP. In the future, the associative factors of NSP incidence should be studied more, and the practices related to health screening and pain prevention should be defined in accordance with today's challenges.

Keywords: Neck Pain, Accelerometry, Exercise, Sedentary Behavior, Physical Fitness, Child

TIIVISTELMÄ (ABSTRACT IN FINNISH)

Pirnes, Katariina Pauliina
Kouluikäisten lasten niska-hartiakipujen yhteydet fyysiseen aktiivisuuteen, paikallaanoloon ja kunto-ominaisuuksiin
Jyväskylä: Jyväskylän yliopisto, 2023, 81 s. + alkuperäiset julkaisut
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Tämä väitöskirja koostuu neljästä alkuperäistutkimuksesta, joissa arvioitiin 10–15-vuotiaiden reippaan tai rasittavan fyysisen aktiivisuuden, paikallaanolon, ruutuajan ja fyysisten kunto-ominaisuuksien yhteyksiä niska-hartiakipujen esiintyvyyteen ja ilmaantuvuuteen.

Ensin tutkittiin kouluikäisten lasten (N=206) web-pohjaisen kipukyselyn toistettavuus. Kahden vuoden seurantatutkimuksessa selvitettiin eri tekijöiden yhteyttä lasten (N=970) itseilmoittamiin niska-hartiakipuihin: 1) poikkileikkaustieto kiihtyvyysanturein mitatusta fyysisestä aktiivisuudesta ja paikallaanoloajasta, 2) kahden vuoden seurantatiedot kiihtyvyysanturi-mittauksista ja itseilmoitetusta fyysisesti passiivisesta ruutuajasta, 3) tulokset Move!-kuntomittauksista alkutilanteessa ja vuoden mittauspisteessä.

Päätutkimustulokset olivat, että kipukysely todettiin luotettavaksi menetelmäksi lasten niska-hartiakipujen havaitsemiseen. Viikoittaisista niska-hartiakivuista raportoi yli neljännes ja kipujen ilmaantuvuus oli 15 % ensimmäisen ja 18 % toisen seurantavuoden aikana. Päivittäin 30 minuuttia tai enemmän reippaasti liikkuvilla pojilla oli 36 % pienempi todennäköisyys viikoittaisiin niska-hartiakipuihin kuin vähemmän aktiivisilla. Paikallaanoloaika ei ollut yhteydessä niska-hartiakipuihin eikä seurannassa reipas fyysinen aktiivisuus, mutta itseilmoitettu fyysisesti passiivinen ruutuaika pelaamisen ja sosiaalisen median käytön osalta olivat yhteydessä niska-hartiakipujen ilmaantuvuuteen ensimmäisen vuoden aikana. Tunnin lisäys ruutuaikaan päivässä nosti kipujen ilmaantuvuusriskin nelinkertaiseksi. Hyvät fyysiset kunto-ominaisuudet eivät johdonmukaisesti olleet yhteydessä niska-hartiakipujen vähäisempään ilmaantuvuuteen.

Johtopäätös on, että fyysisesti passiivinen ruutuaika on riski niska-hartia-alueen terveydelle ja kasvuympäristöjen toimia tarvitaan ongelman ennaltaehkäisyssä. Reipas tai rasittava fyysinen aktiivisuus näyttää torjuvan ainakin poikien niska-hartiakipuja. Jatkossa niska-hartiakipujen ilmaantuvuuden taustaa tulisi tutkia lisää ja määritellä terveysseulontaan ja kipujen ennaltaehkäisyyn liittyvät käytännöt nykypäivän haasteita vastaavaksi.

Avainsanat: Niska-hartiakipu, Kiihtyvyysanturi, Liikkuminen, Ruutuaika, Fyysinen kunto, Kouluikäiset

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In my work as a physiotherapist in Espoo in Southern Finland, I have noticed that more children suffering from neck and shoulder pains come to the appointment. This somehow woke me up, and in 2015, I ended up asking my faculty what the dissertation process entails. Professor Arja Häkkinen, the supervisor of my pro-graduation thesis, was aware of the research related to Finnish Schools on the Move! programme coordinated by the LIKES Research Center for Physical Activity and Health and helped me by asking about the possibility to utilize the research material of that program in the dissertation. Cooperation and familiarization with the material began through joint meetings. As a result of the meetings at LIKES, a research plan was created, for which the extensive research data from LIKES was used. In 2016, I joined the doctoral program at the University of Jyväskylä (JYU), and that is where my path as a PhD candidate really began. The years of the dissertation work have been multi-phased and instructive in many ways. Here, I want to express my gratitude and appreciation to everyone who have helped and supported me over the years.

First, I have been privileged to work with the guidance of a top research group, and it is a valuable experience that I will cherish for the rest of my life. To my supervisors Tuija, Jouni, Arja and Arto, I have learned a lot from you over the years and I thank you for the important guidance I received. To my coauthors Harto, Anna, Kirsti and Laura, thank you for your cooperation and patience—for all the effort. Second, I would like to thank the staff at JYU and Physiotherapy team and LIKES Research Center for Physical Activity and Health (Likes, Jamk University of Applied Science since 1.1.2022). You have given me the opportunity and tools to achieve this goal. Special thanks to my beloved research group "Lillin kuusikko" with Marjo-Riitta, Sari, Maarit, Mirjami and Sara. You have encouraged me and helped me through my hard times and joys. Third, I want to thank my parents, friends, everyone, who have supported me and been interested in my progress and well-being. I have heard that a researcher should stay close to practice to maintain versatile perspective. This, I will confirm with my own experience. Special thanks to my colleagues in the field of Physiotherapy. My children, Henrietta, Kristian, and Aurelia, by being my window into the world of youth, you have enabled me to deeply understand that the work for the well-being of young people is important. Always remember; studying can be done at any age and it is rewarding and keeps the mind fresh. Heikki, my husband, I thank you for keeping our home standing, despite everything. I love all of you.

Kirkkonummi 8.3.2023
Katariina Pirnes

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ORIGINAL PUBLICATIONS AND AUTHOR CONTRIBUTION

The dissertation is based on the following original publications, which are referred to in the text by their Roman numerals (I–IV).

I. Pirnes, K. P., Kallio, J., Siekkinen, K., Hakonen, H., Häkkinen, A., Tammelin, T. (2019). Test-retest repeatability of questionnaire for pain symptoms for school children aged 10-15 years. *Scandinavian Journal of Pain*, 19(3), 575-582. https://doi.org/10.1515/sjpain-2018-0338.

II. 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.

III. Pirnes, K. P., Kallio, J., Hakonen, H., Hautala, A., Häkkinen, A. H., Tammelin, T. (2022). Physical activity, screen time and the incidence of neck and shoulder pain in school-aged children. *Scientific Reports*, 12, 10635. https://doi.org/10.1038/s41598-022-14612-0.

IV. Pirnes, K. P., Kallio, J. J., Hakonen, H. J., Hautala, A. J., Joensuu, L., Häkkinen, A. H., Tammelin, T. H. (2022). Physical fitness characteristics and neck and shoulder pain incidence in school-aged children – a two-year follow-up. *Health Science Reports*, 5, e852. https://doi:10.1002/hsr2.852.

Doctoral candidate Pirnes was the first author in all studies and responsible for the writing and article publishing processes. The data was pre-collected, related to the larger research project of the Finnish Schools on the Move! programme during 2013–2015. The statistical analysis was performed by statistical experts at Likes, and the interpretation of the results was made in collaboration with the entire research group.

FIGURES

TABLES

ABBREVIATIONS

CI	Confidence interval
FIML	Full information maximum likelihood
HBSC	Health behavior in school-aged children
IASP	The international association for the study of pain
ICC	Intraclass correlation coefficient
ICT	Information and communication technology
MET	Metabolic equivalent of task
MVPA	Moderate-to-vigorous physical activity
NP	Neck pain
NS	Neck and shoulders
NSP	Neck and shoulder pain
OR	Odds ratio
PA	Physical activity
SD	Standard deviation
SB	Sedentary behavior
ST	Sedentary time
UQMP	Upper quadrant muscle pain
WHO	World Health Organization

CONTENTS

1 INTRODUCTION

"Making children and adolescents lives more visible by giving a greater focus on their specific needs and including policy and programme developments based on child rights at all levels will contribute to a stronger impact on their health and well-being" (World Health Organization /Europe policy, 2022).

A global systematic scientific assessment shows that global health is improving (Vos et al., 2020). However, musculoskeletal problems are gaining more ground than in earlier assessments (Vos et al., 2020). The increase in neck and shoulder pain (NSP) in young people was observed to occur approximately at the turn of the 1990s when information and communication technology (ICT) also began to become more common (Hakala et al., 2002; King et al., 1996). It has been reported that NSP has become one of the most persistent symptoms of musculoskeletal pain among the youth (Mikkelsson et al., 1997; Mikkelsson et al., 1999). Despite these observations, an overall picture of the phenomenon has not been formed, and therefore, we cannot say what the usual factors behind the increasing NSP are. In short, longitudinal studies are insufficient regarding children's NSP. Various genetic and environmental factors are probably influencing the onset of NSP simultaneously (Kazeminasab et al., 2022); however, we need to understand what they are and how they affect, particularly environmental factors, to prevent pain. The preventive perspective is particularly important in this context, as well as in this dissertation, because lifelong health habits are created during younger years, and these habits affect not only the present but also future well-being (Butler et al., 2011).

NSP is a serious public health problem for the entire population, according to the Global Burden of Disease Study 2017, and the highest point - prevalence of NSP can be seen in Norway, Finland, and Denmark (Safiri et al., 2020). Therefore, especially from a Nordic perspective, increasing awareness of the risk factors and prevention strategies of NSP is important with the help of new research results. By preventing increasing NSP in school-aged children, we may also influence the NSP in adulthood, which is a heavy burden on health care and society. In 2016, for example, out of 154 different diseases, neck pain

(NP) had the largest share of health care expenditure in the US in addition to lower back pain (Dieleman et al., 2020).

School-aged children, the age group of this dissertation, are in critical transition in their lives, facing many pressures and challenges, changes in social relationships with family and peers, growing academic expectations, and both rapid physical and emotional changes related to maturation (World Health Organization, 2016). The ages between 10 and 15 years are the era of increasing independence, when children's own decision-making develops, and which can thereby also affect an individual's health and health behavior. This pattern of behavior can continue into adulthood, affecting an individual's mental health, the development of health problems and health choices, physical activity (PA), and diet (World Health Organization, 2016).

This dissertation is inspired by the WHO's (World Health Organization) view on their "Health Behavior in School-Aged Children" -surveys, cited in the beginning, and Article 12 of the United Nations Convention on the Rights of the Child (United Nations, 1989), which enshrines the children's right to be heard, respected, and considered. Young, growing people are often neglected as a population group in health statistics, being combined with either younger children or young adults (World Health Organization, 2016). As every individual, also young, growing people are experts in their own lives, and therefore, their active participation in research relevant to them is necessary (World Health Organization, 2016). This dissertation aimed to find out the test–retest repeatability of the used pain questionnaire and possible associations between the self-reported NSP prevalence and PA or sedentary time (ST) in a cross-sectional study setting. It also aimed to study the associations between PA, ST, physically passive screen time, and physical fitness characteristics with the NSP incidence in a longitudinal study setting.

2 REVIEW OF THE LITERATURE

"Scientific and medical definitions are tools. Even when we recognize them as imperfect or provisional, awaiting replacement by an improved version, they perform work that cannot be accomplished by less precise instruments"
(Morris 2003).

2.1 Concepts of the dissertation

Many different definitions and terms have been used in studies on NSP in children. Variating terminology is also used for other main factors in this dissertation. Therefore, the chosen concepts used in this study are described and specified under the following headings.

2.1.1 School-aged children

Compulsory education begins the same as the school year a child turns 7 years (Oppivelvollisuuslaki 1214/2020, 2§) ending at the age of 18 in Finland or if a degree referred to the Matriculation Examination Act (502/2019) or the Vocational Education Act (531/2017) is completed or other equivalent education in Åland or abroad is successfully completed previously (Oppivelvollisuuslaki 1214/2020, 2§). Furthermore, according to the Finnish law, a person is considered a child, until he or she is aged 18 years and as a young person between 18 and -24 years (Lastensuojelulaki 417/2007, 6§).

The term "school-aged children" has been chosen to refer to a largely school-based research environment and sample. The research collaboration of WHO, the "Health Behavior in School-Aged Children" (HBSC), monitors the health of 11-, 13- and 15-year-olds every 4 years in 51 countries and regions in Europe and North America, and uses the term "school-aged children" for these ages internationally. It is noteworthy, however, that during the years between 10 and –15, a child usually undergoes major changes both biologically and academically (Malina, 2004). The pubertal spurt will begin approximately at the age of 10 in girls and 12 in boys, and ends at 15 and 17 years, respectively. Genes and treatment (e.g., nutrition, medications, and diseases) can affect the development of individual height and weight (Taranger & Hägg, 1980). The participants of this study are in the beginning or in the middle of their growth, development, and maturation being 10–15 years old at the time of the study. However, the research data do not include information about the growth stage of the participants, and the term "school-aged children" is used for the study population for this reason as well.

Differences in growth, maturation and development can be large (Malina, 2014). Growth means an increase in body size, while different parts and proportions of the body grow and change at different rates and at different times (Malina et al., 2004). Maturation refers to progress toward biological maturity, and development refers to the refinement of behavior (Malina et al., 2004). Between 10 to 15 years, children are receptive to the models they see in their environment and culture, and they seem to prefer immediate rewards (Steinberg et al., 2009). In particular, the age range of 13–16 would seem to be important, influencing the relative preference of individuals for long-term rewards (Steinberg et al., 2009). However, the processes are related to individual growth and interact between individuals and cultural groups. Therefore, it is also important to understand the growing years from a biocultural perspective (Malina, 2014).

2.1.2 Neck and shoulder pain

The International Association for the Study of Pain (IASP) has accepted a revised definition of pain in 2020, which is, "An unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage" (Raja et al., 2020). Chronic pain, again, is defined as "persistent or recurrent pain lasting more than three months" (Treede et al., 2015). Thus, the used 3-month recall period is on the borderline of the definition of chronic pain. NSP reported by school-aged children with a frequency of at least once a week (weekly) has been studied. This could also be called recurrent NSP (Siivola et al., 2004). A Norwegian study in adolescents aged 13- to 19 years in 2006–2008, again, defined the pain "not related to any known disease or injury, for at least once a week during the last three months", as "chronic idiopathic pain" (Hoftun et al., 2011).

According to IASP definitions, the studied NSP can be classified also as "musculoskeletal pain" (Treede et al., 2015). Chronic musculoskeletal pain is "continuous or recurring pain that occurs as a part of the disease process and directly affects the bone(s), joint(s), muscle(s), or related soft tissue(s)", but does not include such pain that arises from compression of neural pathways or is somatic type (Treede et al., 2015). As the etiology of the studied pain is not known in more detail, a definition of "chronic primary pain" of NS area, could also have been used according to the latest definitions (Treede et al., 2015). Thus, the focus behind the term "neck and shoulder pain" of this study is in non-specific, non-traumatic NSP, as the cases where pain was reported to have a traumatic origin were excluded based on children's responses.

In the questionnaire, the pain areas of the body were presented to the children in a human body figure, where it can be seen; pains marked in the NSP area could be located also in the upper trapezius area. In the English study reports of the original articles of this dissertation, the common English term "neck and shoulder pain" has been used, as the original Finnish term "niska-hartiakipu" does not have a suitable English counterpart. Therefore, one must note, the Finnish equivalent of the expression does not mean the shoulder area and thus a part of the upper limb, but the area that is understood as the upper part of the trapezius muscle. Some of the background literature has investigated only NP, but in some cases, a similar pain area has been considered (Grimmer et al., 2006). This literature overview mainly includes such studies that have studied NP or NSP in terms, but exceptions may occur, for example, if the NS area have been examined as separate pain areas (Ben Ayed et al., 2019).

2.1.3 Physical activity and sedentary time

School-aged children PA refers to all accelerometer-measured moderate-to-vigorous physical activity (MVPA) along the studies. Similarly, ST refers to the total ST of accelerometer wearing time during daytime. MVPA was chosen as the investigated intensity as MVPA was considered to be clinically significant in terms of its health benefits for school-aged children, and as it is separately integrated into PA recommendations for the studied age group (Bull et al., 2020; Ministry of Education and Culture, 2021). Self-reported physically passive screen time (Kallio et al., 2020), as an activity representing sedentary behavior (SB) included in the total ST (Tremblay et al., 2017), has been studied as one possible NSP-associated variable.

2.1.4 Physical fitness characteristics

In this dissertation, the particular interest was in health-related physical fitness, which can be measured with field-based measurements in school-aged children. Health-related physical fitness is generally thought to be more related to public health than performance-based physical fitness or athletic fitness (Caspersen et al., 1985). The measured physical fitness characteristics are included in the Move! test battery for field-based measurements in the school environment, and these characteristics represent the health-related physical fitness of the children (Joensuu et al., 2018) by describing their flexibility, muscular fitness, fundamental movement skills, and cardiorespiratory fitness. As the characteristics of health-related physical fitness are not thought to be interdependent (Caspersen et al., 1985), they are studied separately; for example, a person may be strong, but lack flexibility.

However, the characteristics of physical fitness cannot be completely separated from each other. The overlap is noted in more detailed descriptions of characteristics, which expand the concept behind the term. For example, the definition of muscular fitness includes both muscle strength and endurance (Garber et al., 2011). Flexibility refers to the range of motion of joints, which in turn is affected by the trajectory of muscles and tendons (Garber et al., 2011). Neuromotor fitness is practiced with balance, agility, and coordination tasks that require motor skills (Garber et al., 2011). In this study the aforementioned fitness characteristic has been referred to as "fundamental movement skills" (Lubans, 2010), which have been recommended to be described as "building blocks" for the development of more advanced and complex movements (Logan et al., 2018).

2.2 Neck and shoulder pain among young population

NSP is common in childhood around the world. In age-standardized rates, the years lived with disability are the highest in Western Europe and East Asia (461/100, 000) in the general population (Safiri et al., 2020). The neck and shoulder are the most common pain sites among young people according to many studies (Aartun et al., 2014; El-Metwally et al., 2004; Hoftun et al., 2011; Mikkelsson et al., 1997), and NP appears to be the frequent type experienced by about 5% of young people (Ståhl et al., 2008).

2.2.1 Prevalence

NSP prevalence varies depending on the source. About 15–41% of school-aged children have been reported to experience NSP at least once a week (Aartun et al., 2014; Hakala et al., 2006; Mikkelsson et al., 1997; Myrtveit et al., 2014; Vikat et al., 2000). During the 1990s a steady weekly increase in the prevalence of NSP was noted in school-aged children (Hakala et al., 2002; Hakala et al., 2006; Siivola et al., 2004). Studies since have noted that NSP increases as children age (Hakala et al., 2006; Keeratisiroj et al., 2018; Myrtveit et al., 2014; Ståhl et al., 2004), and as the frequency of occurrence increases, the intensity of pain tends to increase linearly (Ståhl et al., 2004). NSP occurs commonly together with other musculoskeletal pain than alone (Ståhl et al., 2004). Girls have been reported to experience more NSP than boys (Ben Ayed et al., 2019; Diepenmaat et al., 2006; Keeratisiroj et al., 2018, Myrtveit et al., 2014; Vikat et al. 2000) and early maturing girls appear to be at higher risk for chronic NSP (Kløven et al. 2017).

Comparing studies due to different pain definitions and outcome measures of NSP is difficult, if not impossible. Studies on the prevalence of NSP, which are somewhat comparable to this dissertation study, are shown in Table 1. A population-based study with more than 500 participants was considered a comparable study. In addition, to have the best possible comparability, studies including 10- to 15-year-old school-aged children were screened, and weekly NSP from the last 3 months before survey was examined and reported separately. Overall, the prevalence of NSP in the most comparable study populations varies between 15% and –33%, and in percentage terms, NSP is reported to be more common among girls in every study (Table 1). The differences in NSP are shown in Table 1; in the Norwegian reports on NSP prevalence, the percentage is higher than in the Finnish reports.

TABLE 1 Prevalence of weekly (pain at least once a week during the previous 3 months) non-traumatic neck pain (NP)/-neck and shoulder pain (NSP) in studies with original population of more than 500 school-aged children.

Author, year, country	**Sample, pain assessment method, study year**	**Age, years**	**Final sample (respons rate %)**	**Prevalence NP/NSP**
Mikkelsson et al. 1997, Finland	Primary school children, classroom questionnaire, 1995	9-12	1756 (83%)	All 15%, Girls 16%, Boys 14%, NP
Rossi et al. 2016, Finland	The Finnish Health Promoting Sports Club (FHPSC) study, survey, 2013	14-16	962 sports club member, 675 non-member	Girls 20%, Boys 5%, NSP
Kløven et al. 2017, Norway	The YOUNG-hunt3 girls, classroom questionnaire, 2006-2008	13-18	3982	<12 years 33% (early), 12-14 years 22% (normal), >14 years 20% (late), NSP in relation to menarcheal age
Jahre et al. 2021, Norway	Ungdata survey, classroom questionnaire, 2017-2019	13-15 16-19	226552 (87% of lower, 72% of upper secondary school)	All 24%, Girls 33%, Boys 16%, NSP

Ergonomics at school and psychosocial factors have been found to affect NSP; (Ben Ayed et al., 2019; Brink et al., 2015; Dianat et al., 2018; Gheysvandi et al., 2019) for example, tiredness, depressive symptoms, and screen-based activities have been reported to be associated with greater NSP prevalence, particularly among young people (Auvinen et al., 2010; Myrtveit et al., 2014; Pollock et al., 2011). In addition, NSP in young people rarely occurs as an independent or separate symptom, but it typically occurs simultaneously with, for example, headache, other musculoskeletal pains, or depressive symptoms (Jahre 2021). NSP symptoms are also partly responsible for the increased health care consultations among school-aged children (Myrtveit et al., 2014).

2.2.2 Incidence

This dissertation has a special reference to the NSP incidence of school-aged children for which only little information is available thus far, and not much is known about the factors associated with in the studied age group. Incidence is defined as new cases of a disease during a specified time (Aartun et al., 2014; Siivola et al., 2004), and when children are studied, this is particularly interesting, as they have less pain experience and history than adults. Comparing and synthesizing existing research data are difficult, as the definitions of pain, pain intensity, and recall times vary widely in studies. Therefore, evidence-based understanding and perceptions of NSP incidence in school-aged children are limited. Table 2 presents the longitudinal studies initiated in school age, in which the incidence and associative factors in NSP, NP, or upper quadrant muscle pain (UQMP) incidence have been reported. No recent studies on the subject have been published.

For adults, a systematic review reported an overall NP incidence rate of 16.2% and identified psychosocial, physical, and individual-level factors associated with a first (pain-free at baseline) episode of NP (Kim et al., 2018). The strongest risks for NSP incidence were depressed mood, perceived role of conflicts, and perceived muscle tension in the psychosocial category, and the most frequently reported significant physical NP risk was working in fixed positions. Leisure-time PA was a protective factor for NP incidence in this systematic review. The only significant risk factor for NP incidence at the individual level was high body mass index (BMI) (Kim et al., 2018).

For school-aged children, the reports of NSP incidence of at least 6 months varies between 10% to -60%, depending on the study. For example, Ehrmann Feldman et al. (2002) reported an annual cumulative NP incidence of approximately 10% among 13- to 15-year-old Canadian children (N=502). In that study, NP occurring at least once a week in the previous 6 months was noted at baseline, 6 months after, and 1 year after baseline. Siivola et al. (2004), however, reported an NSP incidence of 59%, among older, 15- to 18-year-old school children. The incidence included both occasional and weekly episodes of NSP during the 6 months preceding the second study, which was conducted 7 years after the first one. The results of the study of Poussa et al. (2005) revealed the lifetime cumulative NP incidence to be 78% among girls and 58% among boys. They defined the pain incidence as occurring on at least 8 days during the past year at follow-up measurements (Poussa et al., 2005). All levels of NP were also included in an Australian study in 13- to 17-year-old children (N=132); however, in that study, the annual incidence of NP was reported moving from only approximately 6 to 9 percent in girls and approximately 11 to 4 percent in boys between baseline and end of follow-up (Grimmer et al., 2006). The survey was performed five times annually during the study years 1999–2003 (Grimmer et al., 2006). El-Metwally et al. (2007) found the NP incidence to be approximately 10% in their prospective study for ~11-year-old Finnish children (N=1113), and the NP occurring at least once a week was included in this number. The weekly NSP occurrence in some follow-up point was observed to be 28% by Ståhl et al. (2008) among third and fifth grade children. A cumulative UQMP incidence of 26% after 6 months was reported by Brink et al. (2009) among older, 10th grade pupils. The 2-year cumulative incidence of NP ("never" pain at baseline and any frequency of pain on a six-point scale at follow-up 2 years later) was 60% in 11- to 13-year-old children, according to a report by Aartun et al. (2014).

In the absence of specific longitudinal studies on the NSP incidence, only a few factors have been identified as possible determinants of the NSP incidence in school-aged children, including long follow-ups extending to adulthood. Psychosomatic stress symptoms have been found to predict NSP later in adulthood (Siivola et al., 2004). A 25-year follow-up study evaluating the predictive values of fitness characteristics showed that boys with the best flexibility level had the least tension neck symptoms in adulthood (Mikkelsson et al., 2006). However, girls with the best flexibility were most likely to have tension neck as adults. A good performance in bench press at age 16 was found to be associated with a lower risk of NSP in males (Barnekow-Bergkvist et al., 1998). Poussa et al. (2005) studied 11- to 14-year-olds under 22 years of age and their anthropometric measurements and associations with NP incidence (structured questionnaire) in a population-based study (N=430). Short stature at age of 11 years was predictive in NP incidence; however, researchers concluded that anthropometrics played only a modest role in NP incidence in the study (Poussa et al., 2005). In boys and girls (N=769), some other physical and psychological symptoms, such as headache, abdominal pain, daytime fatigue, depressed mood, and difficulty sleeping occurring at least once a week, as well as other weekly musculoskeletal symptoms in girls, predicted the occurrence of weekly NP in the study of Ståhl et al. (2008). They also found that the NSP occurrence in children is largely fluctuating in nature (Ståhl et al., 2008).

An unambiguous summary of the NSP incidence and associative factors is difficult to make. Both NSP incidence and factors associated with it that have been investigated in other studies, are shown in Table 2. Research in the studied area is fragmented, and no common picture of the NSP incidence in school-aged children is noted, let alone factors that affect the incidence. The currently available research information on the factors associated with NSP incidence can be said to be focused on studying psychological background factors that appear to have an association with the NSP incidence based on the data in Table 2. However, the direction of this association is not known. Overall, the research on associations of other underlying factors for NSP incidence in children is weak.

TABLE 2 Studies on reported neck pain (NP), neck and shoulder pain (NSP), or upper quadrant muscle pain (UQMP) incidence and the factors associated with it.

Author, year, country	**Sample, pain assessment at baseline/follow up, study years**	**Age at baseline/ follow-up**	**Follow-up sample (response rate %)**	**Pain definition, incidence/ occurrence (%)**	**Findings associated with incidence/ occurrence**
Ehrmann Feldman et al. 2002, Canada	7th–9th grade pain-free students, questionnaire, 1995–1996	Mean 13.8 years	502 (62)	Annual cumulative NP at least once a week (10), neck and upper limb together (29)	Working and poorer mental health status
Siivola et al. 2004, Finland	High school students with no NP ever (pain-free), classroom questionnaire/ postal inquiry, 1989/1996	15–18/ 22–25	394 (48)	6 months incidence of occasional or frequent NSP at follow-up (59)	Psychosomatic symptoms, NSP in adolescence, dynamic sports loading upper limbs protected from later NSP
Poussa et al. 2005, Finland	4th grade children, anthropometric measurements/ structured questionnaire, 1986/2008	11/22	430 (40)	Any NP incidence cumulating >8 days during last year at follow-up (78 girls, 58 boys)	Short stature at 11 years of age, male gender protective
Ståhl et al. 2008, Finland	3rd and 5th grade children with 61% pain free at baseline, questionnaire, 1995/1996, 1999	9–12/ 13–17	1268 (72)	Weekly NP in some follow-up point and pain free at baseline (28)	Other weekly musculoskeletal pain in girls; other physical and psychological symptoms in boys and girls
Brink et al. 2009, South Africa	10th grade pain-free students working on desktop computers, questionnaire, 2007	15–17	93 (89)	Three and 6 months of any UQMP incidence during the previous month. (3/10 girls, 12/14 boys) cumulative incidence of 6 months (26)	An extreme cervical angle or/and cervical/thoracic angles

2.2.3 Assessment of neck and shoulder pain

The accurate identification of children's pain symptoms is the first step in preventing and minimizing pain among school-aged children. Understanding the nature of the NSP in children is necessary when identifying the factors correlated with NSP in today's young population. By studying information on the true, non-cumulative NSP incidence among school-aged children, we could observe the phenomenon in detail and add evidence, for example, regarding the "susceptibility period", associated with the incidence of NSP.

Mainly structured interviews (Wedderkopp et al., 2009), parental reports, and self-reports have been used in assessing NSP in children. Self-reported pain or alternative reports from parents could be considered as a bias-risk, when the pain is dependent on memory. Conversely, parents could be unaware of the pain of their children (Chiwaridzo & Naidoo, 2015). The interview as a research method is not suitable when studying large populations, although, an interview could be used to obtain valuable information about the pain experienced by the children, in particular (Kortesluoma et al., 2003). The interviews are sensitive to disturbances, which should be known and noted in advance (Kortesluoma et al., 2003). Dionne et al. (2008) stated that measurements evaluating not only the prevalence of pain but also the recurrence, intensity, and disability caused by it would be optimal for detecting the consequences of pain in younger age groups, as the years of growth might change the situation. Wedderkopp et al. (2009) reflected on studies evaluating back pain and stated that, ultimately, no method exists to confirm the presence or absence of pain. Pain is always subjective. However, easily implemented, age-appropriate, and well reproducible pain assessment tools that are inexpensive, to assess pain in large population-based studies in school-aged children, come into question. Thus, the pain assessment tools in current studies differ from therapeutic pain management measures, which are not discussed in this dissertation.

Older children have been found to be more reliable respondents to surveys than younger ones (Bae et al., 2010). They are reportedly better at reading and understanding what they read and therefore produce a better quality of information than younger children according to Borgers et al. (2000). One must note that through their lives, individuals learn about their pain sensations (Raja et al., 2020) and children cannot be as experienced with their pain sensations in their early lives. Thus, individuals' own experience and report should always be respected (Raja et al., 2020) both in clinical environments and in research, and the individual's development should be considered in the selection and interpretation of the measurements and results.

2.3 Physical activity and school-aged children

For people of all ages, studies have shown the protective effect of PA against non-communicable diseases (Jonker et al., 2006; Strong et al., 2005), and a sedentary way of living has been found to be a risk factor for these diseases such as stroke, coronary heart disease, obesity, high blood pressure, type-2 diabetes (Mokdad et al., 2000). The relationship between MVPA or ST and NSP in school-aged children has been investigated in studies II and III, as their role in promoting adolescent health is widely recognized (Janssen & Leblanc 2010; Straker et al., 2016); however, the information on the effects of MVPA on NSP is limited and contradictory. As a decrease in MVPA and a large increase in ST from childhood to adolescence have also been observed (Ortega et al., 2013), their associations with children's health should be further investigated during this important period of life.

For 5- to 17-year-olds, WHO recommends at least 60 min of daily MVPA to improve cardio-respiratory and muscle fitness; support bone health, the cardiovascular and metabolism systems, and health biomarkers; and reduce symptoms of anxiety and depression (Bull et al., 2020). Most of the daily PA should be of the endurance type. Vigorous activity should be included at least three times a week to strengthen the muscles and bones. Suitable exercise for this age group includes play, games, sports, exercise, transportation, recreation, physical education, or planned exercises linked to family, school, or community activities. In addition, ST should be limited and particularly the amount of recreational screen time (Bull et al., 2020).

The recently updated Finnish PA recommendation follows the WHO's view and states that "All children and young people aged 7–17 years are recommended to be physically active in a versatile, vigorous, and strenuous manner, at least 60 minutes a day in a way that is appropriate for the individual's age." In addition, "excessive and prolonged sitting should be avoided" (Ministry of Education and Culture, 2021). According to the recommendations, it is of the child's best interest, even if the recommendation is not fulfilled every day. Anyhow, it is advisable to be physically active every day of the week (Bull et al., 2020; Ministry of Education and Culture, 2021).

According to the WHO's international HBSC data, approximately 28% of 13-year-old children (boys 33%, girls 24%) are physically active at a sufficient level (World Health Organization, 2020) and measured using accelerometers; correspondingly, 19% (boys 24%, girls 15%) accumulate enough MVPA in the national level in Finland (Husu et al., 2019). The number of those who exercise sufficiently varies depending on the method of data collection; however, it is quite low for the average age group of the studied children (mean 12.5 years). The amount of MVPA continues to decrease as children get older and by the age of 15, the amount is 17% (boys 22%, girls 12%) (World Health Organization, 2020) and accelerometer-measured amount is 10% (boys 16%, girls 6%) (Husu et al., 2019).

2.3.1 Defining physical activity levels

PA overall, encompasses all voluntary muscle-strengthening and energy-consuming functions (WHO, 2018). This includes both training and sports as well as everyday activities. PA was defined by Caspersen et al. (1985) as "…any bodily movement produced by skeletal muscles that results in energy expenditure." They also completed a definition by defining that during PA, energy expenditure (kilocalories) varies continuously from low to high and that PA is positively correlated with physical fitness (Caspersen et al., 1985).

Current descriptions of the MVPA that was the focus of the current studies, are unclear, and because of the variation of MVPA limits, connecting intensities with health effects is difficult (MacIntosh et al., 2021). It should also be noted that when an individual adapts to PA or its level, these limits change (MacIntosh et al., 2021). Generally, brisk walking or dancing can be considered examples of moderate PA, whereas jogging, running, fast cycling, or fast swimming can be considered examples of high-intensity PA (MacIntosh et al., 2021) and thus examples of the sufficient-intensity PA.

ST means the total amount time of SBs practiced during the day including, for example, traveling by car, working at a desk, and watching TV (O'brien et al., 2020). SB as a term, is more specifically defined as "any waking behavior characterized by an energy expenditure ⩽1.5 METs (metabolic equivalent of task) while in a sitting, reclined or lying posture" (Tremblay et al., 2017). SB activities include watching television, reading, and working at a computer. Thus, different SB constitute an individual's ST.

The Steering Committee of Canadian Society for Exercise Physiology and Public Health Agency of Canada highlighted in 2009, that SB should be considered an important issue independent of PA (Tremblay et al., 2011). WHO (2010) has also highlighted the lack of scientific reports related to SB. SB may have a direct detrimental effect on metabolism (Saunders et al., 2018), while other effects may be more dependent on the activity itself performed during sitting. Screen time-related SB has reported to have adverse associations with many health determinants among school-aged 5- to 18-year-olds, including body composition, cardiometabolic risk, behavioral conduct, fitness, self-esteem (Carson et al., 2016; Stiglic et al., 2019), and sleep (Carter et al., 2016; Hale et al., 2018). Particularly, sedentary lifestyle, meaning plenty of sitting time and lack of exercise, appear to be quite permanent as a style of living (Telama, 2009).

The first SB recommendations have been developed and published for the school environment (Saunders et al., 2022). According to these evidence-based recommendations, a healthy school day should include interruptions in long sessions and the inclusion of various movements in homework whenever possible, and sedentary homework should be limited (Saunders et al., 2022). The time spent in front of the screen related to school should be meaningful and mentally or physically active and additionally promote learning by supporting the pedagogical plan (Saunders et al., 2022).

2.3.2 Assessing physical activity

A reliable assessment of PA is needed to identify the prevailing activity levels in the population and evaluate the effectiveness of measures that increase activity levels (Adamo et al., 2009). One way to collect information on PA is through subjective, indirect instruments, such as questionnaires, interviews, activity diaries (logs), and direct observation (Corder et al., 2008). Subjective PA assessment is influenced by the ability to accurately remember relevant details retrospectively; however, the opinion or perception of the participant, representative, or researcher can also be affected (Corder et al., 2008). For decades, self-reports in different forms or parental reports have been used commonly to assess children's PA and ST in different ages and in larger population-based studies. However, PA questionnaires still have limited reliability and validity (Shephard, 2003), because of the reasons mentioned above.

In recent decades, easy and lightweight measures have been developed to detect PA directly more accurately in large populations. Accelerometers and pedometers are examples of these kinds of direct measures. Accelerometers are considered more reliable in detecting PA than self-reports, particularly when studying on PA levels in children (Adamo et al., 2009; Lubans et al., 2011). For example, in a systematic review with 83 studies, 72% of all indirect PA measurements overestimated the directly measured PA (Adamo et al., 2009). Both male and female PA data or PA data from both sexes together were studied, and all indirect and direct measures were compared (accelerometer, heart rate measurement or direct observation) which showed an overestimation of PA (Adamo et al., 2009). The big advantage of measuring PA with accelerometers is, that they can be used to evaluate PA or ST in leisure time conditions (Lubans et al., 2011) and quantify the intensity of the activity (Franz et al., 2017).

In accelerometer studies, the assessment of PA intensity can be based logically on accelerometer-measured cut-points. MVPA or some other PA intensity, measured with self-reports or direct monitoring tools, could also be converted into energy consumption value, using previously determined MET values; however, when examining children, it must be noted that adult MET values are not suitable for children (McMurray et al., 2015). METs are related to physical energy consumption formed from multiples of resting metabolic rate, and children have a higher basal metabolism per unit of weight than adults (Butte et al., 2018). For example, running 8 km/h corresponds to 7–8 METs for adults (Ainsworth et al., 2000) and 12.4 METs for children (13–15 years old) (Butte et al., 2018). PA intensities can also be assessed by heart rate range, expressed in relation to the individual maximum heart rate or a percentage of the heart rate reserve (MacIntosh et al., 2021). Moderate exercise contributes 40–59% of aerobic capacity reserve or heart rate reserve, and vigorous exercise, 60–84% (MacIntosh et al., 2021).

2.3.3 Physical activity and neck and shoulder pain in children

It is of great concern that MVPA of school-aged children has been found to have declined internationally (Aubert et al., 2018). As PA levels decrease, it is possible that children will have no time or chance to form a lasting relationship with PA (Aubert et al., 2018). PA and ST have been proposed to be relevant issues in children's overall health (Janssen et al., 2010; Straker et al., 2016);

however, studies on the associations of PA or ST with NSP have reported conflicting results.

Franz et al. (2017) suggested that PA intensity plays an important role in pediatric pain and reported a longitudinal relationship with PA intensity and spinal pain in children aged 6–12 years (N=1205). The shift from sedentary to moderate intensity physical activities was reported to be protective against spinal pain. However, the shift from sedentary to vigorous physical activities was associated with increased spinal pain occurrence. Most active boys (mean age 17.5 years) have higher sum scores for neck, shoulder, and upper back pain during the last 4 weeks, than less active boys according to a Norwegian study (Østerås et al., 2006).

The associations between directly measured PA and NSP in school-aged children have been studied very little to date. The associations of overall musculoskeletal pain with accelerometer-measured PA have been explored only in a few cohort studies where no separate report on association with NSP was available (Aartun et al., 2016; Wedderkopp et al., 2009). However, regarding earlier studies on back pain, it might be concluded that no association exists between accelerometer-measured PA and spinal pain (Aartun et al., 2016; Wedderkopp et al., 2003) or, that moderate PA protects from spinal pain and vigorous activity increases (Franz et al., 2017) or protects (Wedderkopp et al., 2009) the spinal area from pain. A Finnish study showed that a higher amount of accelerometer-measured ST was associated with a 13% higher prevalence of NSP at least once a week in school-aged children who accumulated MVPA less than 60 min per day (Siekkinen et al., 2016).

2.4 Physical fitness

Evidence of the association of fitness and exercise and good health began to accumulate in the 1960s and 1970s, and an interest to develop primarily health-related physical fitness test batteries for youth began to arise (Pate et al., 2012). Caspersen et al. (1985) stated that, "physical fitness is a set of attributes that people have or achieve that relates to the ability to perform physical activity." The research field has been stimulated to answer the questions related to measurements of musculoskeletal fitness in approximately the last 10 years (Plowman, 2014). Particularly questions concerning associations between different physical fitness tests and health risk factors in youth have been in focus (Plowman, 2014).

Physical fitness consists of many different dimensions that include skills and health factors, of which cardiorespiratory fitness and muscle fitness, particularly, have been shown to affect the health of young people positively (Ortega et al., 2008). Physical fitness has been reported as a sign of children's lifestyle, and a healthy cardiovascular metabolism is protective against chronic disease risk in the future (Ekelund et al., 2007; Hurtig-Wennlöf et al., 2007; Ortega et al., 2011). Adiposity has strong negative association with physical fitness, and the increase in fat mass during puberty does not support the increase in physical fitness (Joensuu et al., 2018; Joensuu et al., 2021). Ortega et al. (2011) found in a 6-year prospective study of approximately 600 children of normal weight that the improvement in fitness from childhood to adolescence is associated with a reduced risk of overweight or obesity in adolescence. Children who remain active appear to be the fittest (Baquet et al., 2006). Components of physical fitness have also been found to be moderators of the relationship between genetic risk and BMI in young people (Todendi et al., 2021). Weak cardiorespiratory fitness and muscle fitness have also been associated with poorer self-rated health (Padilla-Moledo et al., 2012).

In general, field-based test batteries are considered as feasible and reliable measures of physical fitness (Artero et al., 2011; Ruiz et al., 2011). According to the Toronto model of health-related fitness (Figure 1), the components are morphological fitness, muscular fitness, motor skills, cardiorespiratory and metabolic fitness. These components interact with factors, such as heredity, PA, health, and environmental conditions. The components should be considered and studied carefully, as pain is common, and societies are challenged to create and offer favorable growth environments for children. The interaction of both genetics and possible environmental problems (Kazeminasab et al., 2022) must be considered. In this dissertation, the focus is on investigating associations of health-related physical fitness to NSP (health) experienced by school-aged children and defining the usability of the results of the field-based physical fitness measurements in predicting children's NSP as a potential health criterion for extensive, commonly used field-based measurements.

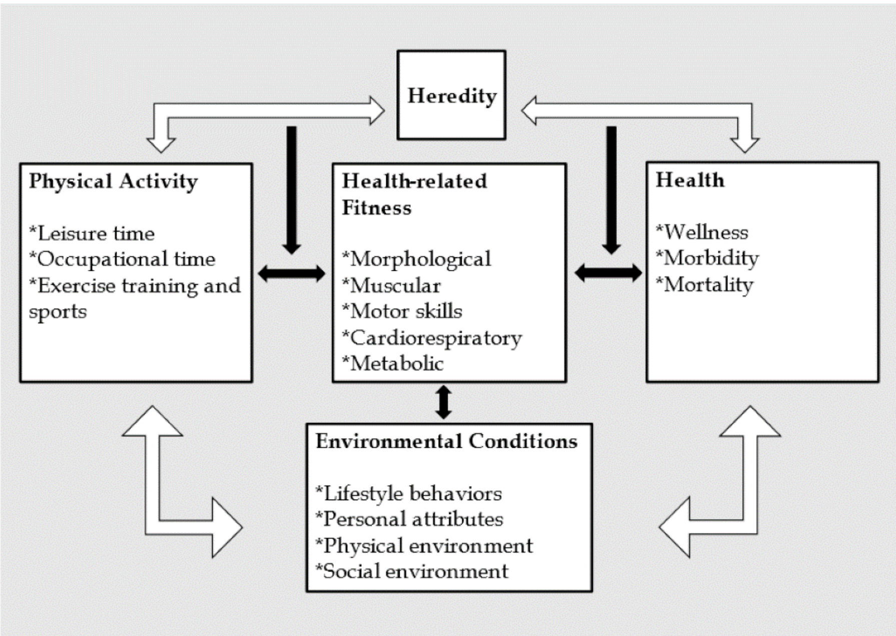

FIGURE 1 Toronto model of health-related fitness. Modified with permission from Bouchard and Shephard (1994).

2.4.1 Defining physical fitness characteristics

The physical fitness characteristics have been evaluated for different purposes and aims and the definition have changed and expanded in terms of these variating purposes. The physical fitness characteristics of this dissertation are found in Move! monitoring system for a physical functional capacity including flexibility, muscular fitness, fundamental movement skills, and cardiorespiratory fitness (Jaakkola et al., 2012; Joensuu et al., 2018).

Flexibility indicates the ability to move freely in the range of motion of joints (Plowman 2013). In the Toronto model (Figure 1), where the reference framework in its scope is presented for health-related fitness, flexibility is not mentioned (Bouchard & Shephard, 1994). However, Caspersen et al. (1985) mentioned flexibility as a component of health-related fitness along with cardiorespiratory endurance, muscular endurance, muscular strength, and body composition. Flexibility is commonly included in field-based measurements for children (FitnessGram, EUROFIT, Move!); however, the research data have not been able to consistently demonstrate a relationship between flexibility and health, particularly among children, where flexibility could be logically or mechanically linked to an individual’s health, such as in the prevention of lower back pain or injuries (Ruiz et al., 2009). For example, flexibility has not been included in the measurements of the ALPHA (Assessing Levels of Physical Activity and Fitness) test battery (Ruiz et al., 2011). Based on a review, however, flexibility is recommended to be considered when measuring physical fitness in young people and in general fitness assessments because of its possible connection with health in adulthood (Stodden et al., 2017).

Muscular fitness refers to the muscles ability to work against resistance (Ortega et al., 2008). Muscular fitness has been shown to be associated with traditional and emerging cardiovascular disease risk factors, along with cardiovascular fitness, and both appear to have a combined and cumulative effect on the cardiovascular profile of the youth (Ortega et al., 2008). In addition, improving muscle fitness seems to have a positive effect on bone health as well based on the Ortega et al. (2008) report.

Fundamental movement skills (motor fitness) representing neuromotor skills include balance, coordination, gait, agility, and proprioceptive skills (Garber et al., 2011). Fundamental movement skills and PA have been found to have a strong association (Lubans et al., 2010).

Cardiorespiratory fitness means the ability of the cardiovascular and respiratory systems to supply oxygen to the muscles during heavy dynamic exercise (Howley, 2001). Thus, cardiorespiratory fitness represents the total capacity of the cardiovascular and respiratory organs and enables carrying out physically demanding tasks during any sustained PA (Ortega et al., 2008). Almost all today’s field-based, commonly used physical fitness test batteries for children and adolescents (FitnessGram, EUROFIT, ALPHA, Move!) include a 20-m shuttle-run as a measure of cardiorespiratory health by being the most used field-based test for young people (Tomkinson et al., 2017).

2.4.2 Assessing physical fitness

A prerequisite for an acceptable field-based test is that both the health risk factor and the area of the musculoskeletal system that are tested respond positively to appropriate exercise (Plowman, 2014). Field-based testing batteries to reach a large number of children in a population level are commonly used to measure school-aged children's physical fitness. FitnessGram, EUROFIT, and ALPHA are probably among most common testing batteries in use. Field-based testing batteries, as measures of health-related physical fitness, are considered reliable in the youth (Artero et al., 2011; Ramírez-Vélez et al., 2015). Dynamic movements of the whole body are mainly preferred in field measurements, although measurements could also be made with instruments, for example, with a dynamometer. Laboratory measurements provide the highest evidence related to measuring physical fitness characteristics; however, in fitness monitoring in field circumstances, they cannot be used. Moreover, the testing environment can never be standardized in field-based measurements in the same way as in the laboratory. Therefore, it is good to consider the possible influencing factors in field-based test situations and note their different nature and possible effects compared with those of laboratory measurements.

2.4.3 Physical fitness and neck and shoulder pain in children

Adults prepare environments for children, and they should understand the possible challenges of the environment in maintaining and promoting children's physical fitness, as well as its importance for children's physical ability. This dissertation has been shaped to elucidate further the backgrounds of NSP in children to make preventive work possible.

With the help of cross-sectional studies conducted in adults, NSP can be explained, at least to some extent, through fitness characteristics (Hesselman Borg et al., 2016; Yalcinkaya et al., 2017). In a cross-sectional study, gender differences were reported in association with NSP and fitness characteristics (Yalcinkaya et al., 2017). Aerobic fitness was significantly lower and body fat percentage significantly higher in men with chronic NP than in pain-free men, and among women with chronic NP, hand grip and back-leg strength, suboccipital–paraspinal–C7 pressure pain threshold and health-related quality of life were lower than in pain-free women (Yalcinkaya et al., 2017).

Longitudinal associations of NSP have been found to have different contents than cross-sectional associations (Hesselman Borg et al., 2016). Various work-related characteristics, body composition, PA, and fitness level are factors reported to predict NSP followed from age 16 to 52 years, and high BMI, work-related factors, poor life management, and low social support from ages 34 to 52 years have been found to affect NSP prognosis (Hesselman Borg et al., 2016). One prospective study investigated associations with NSP and cervical spine isometric strength and passive mobility in the adult population, but no relationship was found between these variables (Salo et al., 2012). Overall, longitudinal studies on the role of physical fitness in incidence in childhood are lacking.

Research related to the investigation of the background factors for increased NSP is lacking, particularly in the young population. This study entity aimed to address the information gap of selected main research variables related to NSP in school-aged children. Associations have been studied from PA and ST in variables, which have previously been reported to have conflicting associations with children's NSP. In addition, screen time has been studied, which, in the light of current knowledge appears to be a form of SB that could be related to NSP experienced by school-aged children. Physical fitness characteristics have been studied in relation to the incidence of NSP because this information is especially needed, for example, to confirm the health criteria of test batteries that are used to measure health-related physical fitness in children in the field.

3 AIMS OF THE STUDY

Only a few studies have identified factors contributing to the incidence of NSP (Table 2). An understanding of correlates and determinants among school-aged children, might help in reducing the effect of NSP in the future and global early-stage prevention of the disorder. The main purpose was to investigate the associations between accelerometer-measured MVPA, ST, self-reported screen time, and physical fitness characteristics with NSP or NSP incidence in school-aged population. This study also aimed to investigate the repeatability of the web-based pain questionnaire used to increase the reliability of the studies. The studies were related to the larger national school-based exercise promotion program, Finnish Schools on the Move! programme in 2013–2015. More specifically, the aims of the present dissertation were as follows:

1. To assess, the test–retest reliability of the neck and shoulder pain questionnaire among 10- to 15-year-old school-aged children.
2. To determine if accelerometer-measured moderate-to-vigorous physical activity or sedentary time is associated with neck and shoulder pain among school-aged children.
3. To investigate, if accelerometer-measured moderate-to-vigorous physical activity, sedentary time, or self-reported screen time are associated with neck and shoulder pain incidence among school-aged children during a 2-year follow-up.
4. To study whether good physical fitness characteristics are associated with lower neck and shoulder pain incidence in school-aged children.

4 RESEARCH METHODS

4.1 Participants and study design

This dissertation is part of a wider research project, that is connected to the nationwide Finnish Schools on the Move! programme (Blom et al., 2018) coordinated by Likes. The test–retest reliability of the web-based pain questionnaire used in all original studies included in the dissertation was studied in the first study (I). In study II, the cross-sectional associations between MVPA or ST and NSP were observed, and longitudinal studies (III, IV) were designed to detect the associations of MVPA or ST, physically passive screen time, and physical fitness characteristics to NSP incidence.

Study I aimed to investigate the repeatability of the web-based questionnaire used in detecting NSP in children. Thus, two schools from Jyväskylä region were offered to participate in spring 2015. The final population, consisted of 206 children (Figure 2) from grades 4 to 9 (10–15 years, mean age 13.8, SD 1.8 (56% girls)). Of these, 79 were 10- to 13-year-old primary school children (mean age 11.9, SD 0.9) and 127 were 13- to 15-year-old lower secondary school children (mean age 15.1, SD 0.9).

For studies II, III, and IV, a total of 1710 children (Figure 3) in grades 4 to 7 from nine different Finnish schools were invited to participate in the study, beginning in spring 2013 and continuing to spring 2015. Of these, a total of 970 children (55%) decided to participate and submitted a permit document, which was completed by their guardians for the study. The participation was voluntary, and it was possible to withdraw at any time. In the longitudinal studies (III and IV), the data from all three measurement points were used: spring 2013 (T0, baseline), spring 2014 (T1) and spring 2015 (T2) (Figure 3). For these studies, the weight and height of each child were measured to calculate the BMI ($kg \cdot m^{-2}$). Weight was measured wearing light clothing using bioelectrical impedance analysis (InBody 720, Biospace Co., Ltd, Seoul, Korea).

A portable measuring device (Charder HM 200P scale, Issaquah, Washington, USA) was used to measure children's height with an accuracy of 0.1 cm. The measurement was done twice and if these results differed by more than 0.4 cm, a third measurement was made. The average of the two closest results was used in the analysis.

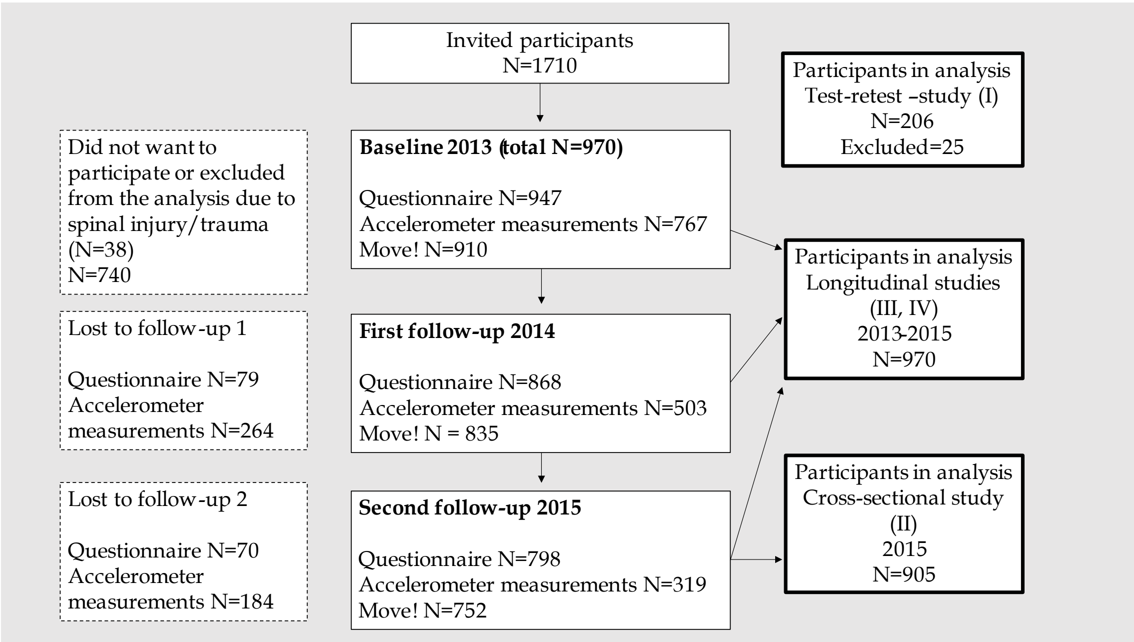

FIGURE 2 Number of the children in studies I, II, III, and IV, and study progress.

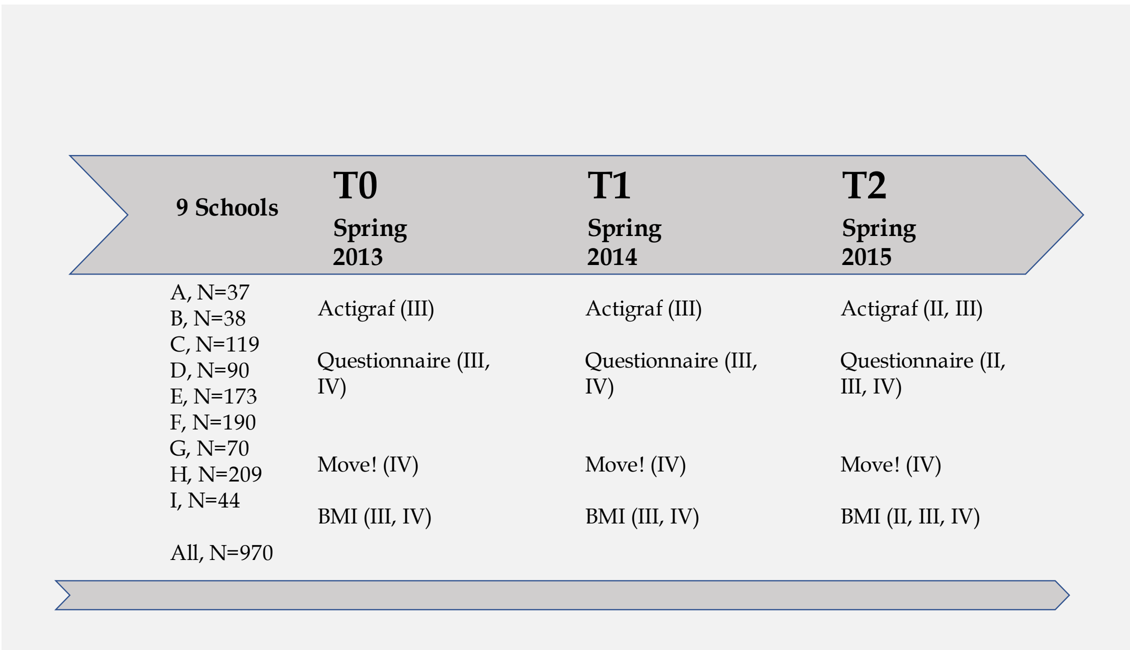

FIGURE 3 Measurement points (T0, T1, T2) in studies II, III, and IV. Populations from nine different schools (A–I). Actigraf = accelerometer.

4.2 Outcome measures

4.2.1 Pain questionnaire (I, II, III, IV)

The questionnaire used in studies (Appendix 1) was previously structured for research purposes in Finland (Mikkelsson et al., 1996; Mikkelsson et al., 1997). The five-level pain frequency classification was originally introduced in the WHO Nationwide Survey on School Health and Health-Related Behavior (King et al. 1996). The test–retest reliability of the web-based version of the questionnaire used was examined through collecting data on the prevalence of pain in different areas of the body (head, NS, upper limb, chest, abdomen, upper back, lower back and buttocks, and lower limb areas) in the past 3 months before filling up the questionnaire (I). The pupils filled out the form twice during school days, and a gap of 2 weeks existed between the filling times. The children reported their pain by answering the question "How often have you had symptoms in the past 3 months?" and chose their answers according to the body areas (Figure 4) where they had experienced pain, such "neck or shoulder pain or ache." For the classification of pain symptoms, five options were given: 1) almost daily, 2) more than once a week, 3) about once a week, 4) about once a month, and 5) rarely or never. A picture of a human body is included in the questionnaire, where pain zones (Figure 4) and corresponding names for the zones are presented to ensure that the children understand the pain areas and can choose correctly. The participants had the opportunity to ask for help from an adult in the classroom while filling in the questionnaire.

In study II, the pain questionnaire was used in determining the prevalence of NSP in school-age children. In studies III and IV, the self-reported data on NSP in three measurement points of the follow-up were used to detect the non-cumulative NSP incidence of the study population. Children were also asked to fill in if they had experienced the pain due to trauma: "In the last 3 months, have you damaged any of the pain areas listed above and pictured (e.g., fallen, tripped, broken during sports, etc.)?" The answer options were "yes" or "no." If they answered “yes,” they were asked to select and mark the injured body area using the human body picture with the pain zones. Spinal trauma-related pains were excluded from the analysis in studies II, III and IV. The English version of the pain questionnaire can be found in Appendix 1.

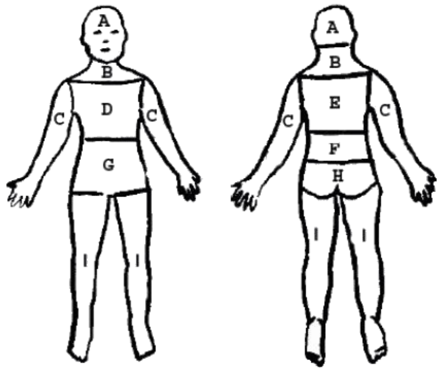

FIGURE 4 Pain areas of the body in the questionnaire.

4.2.2 Accelerometer-measured physical activity and sedentary time (II, III)

ActiGraph triaxial GT3X+ and wGT3X+ accelerometers (ActiGraph, Pensacola, Florida, USA) were used to assess the daytime PA and ST. In the follow-ups, the measurements were carried out at the same time of the year (spring). As an instruction, the children were guided in wearing the accelerometer on the right hip during waking hours. Per instructions, the accelerometer should be kept on for seven full consecutive days in the measurement period; however, during bathing or other water-based activities, the accelerometer has to be removed. Using Actilife software (version 6.11.7), acceleration data were collected as raw 30-Hz accelerations, downloaded, and converted to 15-s epochs. A customized Visual Basic macro for Excel software was used for data reduction. Readings of ≥500 min/day on three valid days (two weekdays and one weekend day) or more, measured between 07:00 and 23:00, were the minimum for a valid monitoring period (Cooper et al., 2015) and a requirement for the analysis. Periods of consecutive zero counts lasting 30 min were defined as non-wear time (Domazet et al., 2016). Over 20, 000 counts per minute (cpm) data were excluded, interpreting them as spurious accelerations (Heil et al., 2012) and the recommended cut off-points (Trost et al., 2011) in accelerometer -studies, proposed by Evenson et al. (2008), were used to calculate MVPA (⩾2296 cpm) and ST (⩽100 cpm) of the children. Accelerometer-based ST was expressed as a percentage of daily wearing time of the measure. 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).

4.2.3 Self-reported screen time (III)

The information obtained from the questionnaire on self-reported screen time was used in analysis between the baseline and 1-year and 1- and 2-year measurement points. Screen time was asked separately for weekdays and weekend days with five different questions concerning different kinds of screen time items (Kallio et al., 2020). Children reported how many hours per day they usually spend 1) watching TV, videos (including YouTube and other sources) or

DVD movies; 2) playing computer or console games (excluding sports games like Wii Fit, Xbox KINECT or Playstation Moves); 3) doing homework on a computer or other electronic device (iPad, etc.); 4) communicating with others through social media such as email, SMS, Twitter, Facebook, and chat; and 5) reading printed or electronic books, magazines, newspapers, etc., outside class hours (e.g. at home, during school breaks, at meal breaks, etc.).

All the questions were possible to be answered by choosing from nine response options: 1) not at all, 2) about half an hour a day, 3) about an hour a day, 4) about 2 h a day, 5) about 3 h a day, 6) about 4 h a day, 7) about 5 h a day, 8) about 6 h a day, and 9) about 7 h a day or more. The answers were coded according to the number of hours: 0, 0.5, 1, 2, 3, 4, 5, 6, and 7. In study III, the screen time was analyzed with the items concerning TV viewing time, game-playing time, and social media time, reflecting particularly the physically passive screen time.

4.2.4 Physical fitness characteristics (IV)

Measurements of physical fitness characteristics at baseline (T0) and 1-year measurement point (T1) were used in the study analysis. These measurements are part of the national Finnish Schools on the Move! monitoring system for a physical functional capacity, which is implemented in the physical education curriculum of Finnish fifth and eighth grade children (Jaakkola et al., 2012; Joensuu et al., 2018). The main purpose in using this field-based instrument in schools is to encourage children to take care of their physical functional capacity independently. The measured physical fitness characteristics of the measurement instrument are flexibility, muscular fitness, fundamental movement skills and cardiorespiratory fitness. The reliability of the different measurements indicating the physical fitness characteristics listed have been reported to be reasonable (Jaakkola et al., 2012).

Flexibility was measured by four tasks consisting of multi-joint measurements, which were lower back extension in sitting posture, squat, and right and left shoulder stretch. The tasks were evaluated according to the criteria 0/1 (0=did not succeed, 1=succeeded). The maximum in flexibility scores was 4 in total, and the minimum score was 0.

In *the squat*, the children were asked to stand straight with their feet shoulder width apart. Arms were raised straight up, and squat was performed as low as they could while keeping the back straight, knees behind toes, hips at a 45° angle, heels on the ground, with feet and knees shoulder-width apart. A score of "1" was recorded if the pupils reached a knee angle of $\leqslant 90^\circ$ and "0" if the knee angle was $> 90^\circ$ and/or the pupils could not maintain the correct posture.

In *the lower back extension*, the children were instructed to sit on their ischial tuberosities towards the floor with both lower legs extended against the surface of the floor. Hands were placed on the thighs. The children tried to straighten their lower back while keeping their knees extended and hands still. The results were scored as 1 if the lower back was extended successfully and as

0 if the lower back was not extended, and/or the child could not maintain the correct posture.

In *the shoulder stretch*, the children were instructed to stand in a vertical position with the spine extended. The children extended their right arm straight up and bent their left arm between the shoulder blades. The children tried to reach their fingers together by bending the right elbow, calmly reaching with the fingers of the right hand to the fingers of the left hand, while keeping their spine in a neutral position. The measurement was then repeated with the hands in opposite roles. The results were recorded for both arms, with the upper arm determining the measurement side (the right hand corresponded to the right-side measurement). The results were scored 1 if the children could extend their fingers together and with a value of 0 when the children could not bring their fingers together, and/or the children could not hold the correct position (Jaakkola et al. 2012).

Muscular fitness was assessed with push-up and curl-up measurements. Push-up (Santtila et al., 2011; Pihlainen et al., 2008) measures especially upper body strength, and curl-up (Jaakkola et al., 2012) measures abdominal strength.

In *the push-up*, the participants were in the prone position, palms on the ground, in line with the shoulders. The hands were in the correct position with the fingers pointing forward and the thumbs at shoulder contact distance. The measurement started from the upper push-up position, where the arms were fully extended, the body was straight, and the feet were shoulder-width apart. Boys had their toes and girls had their knees on the ground. The angle of the hips was 160–180°, and the head was in line with the body. Children bent their elbows, keeping the body in an unchanging position, until the humerus was horizontal, then the position was pushed back up to the starting position. Alternatively, a 10-cm-high object could be placed under their chest to facilitate the assessment. Children performed as many push-ups as possible in 1 min. The result was the number of correctly performed push-ups during the allowed 1-min time.

The curl-up of the Move! measurements is a modified version of the FitnessGram curl-up. For the curl-up, an 8-cm-wide measuring area was marked on the mattress for 5th graders (approximately 11 years old) and a 12 cm wide area for 8th grade pupils (approximately 14 years old). In the beginning of the task, the children took a lying position, with a knee angle approximately 100°. The arms were straight and parallel to the body. The palms were facing down to the mattress, and the fingers were extended touching the nearest edge of the measurement area. The head rested on the mattress on top of the paper, and the heels were on the ground. The children did curl-ups according to the cadence with a sound signal (30 repetitions/min). The pedaling speed was slightly faster than in the FitnessGram curl-up test (20 repetitions/min). The pupils slide their fingers on the opposite edge of the measuring tape, while the heel remained on the ground. They then returned to the starting position and repeated the task until they could not complete the measurement according to the criteria. The number of correctly performed curl-ups was counted at a maximum of 75 (Jaakkola et al., 2012).

Fundamental movement skill measurement includes balance, coordination, gait, agility, and proprioceptive skills (Garber et al., 2011). The fundamental movement skills of the children were evaluated with 5-leap and throwing–catching combination tests.

In *the 5-leap test* (Jaakkola et al., 2009), children tried to jump as far as possible with five consecutive jumps. The first leap, starting behind the marked line, was strained with both feet (1), followed by four alternating one-foot leaps forward (2-5). The last leap ended on both feet (6). The best performance out of two attempts was recorded in meters to the nearest 0.1 m, measured from the heel nearest to the starting line.

In *the throwing–catching combination test* (Jaakkola et al., 2012), a tennis ball was thrown to a 1.5 m × 1.5 m target area on the wall, 0.9 m above the floor. The throwing distance was 7 and 8 m for 5th and 8th grade girls, and 8 and 10 m for 5th and 8th grade boys, respectively. A successful throwing–catching combination included hitting the target area behind the marked line and grabbing the ball on its way back after one bounce. The number of successful throwing–catching combination attempts out of 20 were counted (Jaakkola et al., 2012).

Cardiorespiratory fitness was estimated with the 20-m shuttle run test performance, where running speed was increased in 1-min intervals until maximal voluntary exhaustion. The initial speed was 8.0 -km -h^{-1}, following speed 9.0 -km -h^{-1}, and after that 0.5 -km -h^{-1} per stage (Nupponen et al., 1999). The result was counted as the total number of laps run.

4.3 Statistical analysis

In all studies, descriptive statistics are expressed as mean values, standard deviations (SD) or 95% confidence intervals (CI), and percentages (%) counts. In studies I and II, descriptive statistics were calculated using SPSS 20.0 for Windows (SPSS Inc., Chicago, IL), and in the studies III, and IV, SPSS 25.0 for Windows (SPSS Inc., Chicago, IL). For further analyses, Mplus statistical package (Version 7) was used, and p-values ≤0.05 indicated a statistically significant association. Missing data were assumed to be missing at random (MAR). In studies II, III, and IV, the sampling weights of the modeling considered the unequal probabilities of selection (by age and sex). The sampling weights were constructed based on information on the population structure published by the Official Statistics of Finland. Parameters of the models were estimated using the full information maximum likelihood method (FIML) (Cham et al., 2017) with robust standard errors (MLR). Owing to the grouping of data between schools and age groups, standard errors were calculated using a special feature (TYPE=COMPLEX) in Mplus. The method produces estimates for the standard errors that are robust to non-normality. In studies III and IV, drop outs were considered using FIML, meaning correcting the model with the best estimate that determines the value that maximizes the likelihood function based on the sample data.

In study I, the intraclass correlation (ICC) (3,1), Two-Way Mixed Single Measures for the five-point scale, and Cohen's kappa coefficient (κ) and global percent agreement for a two-point scale, were used to demonstrate the repeatability of the pain questions in the questionnaire. ICC values <0.40 reflect poor, 0.40-0.59 fair, 0.60-0.74 good and 0.75-1.00 excellent repeatability (Cicchetti et al., 2006). Kappa (κ) values of <0.00 and 0.10 to 0.20 represents poor and slight agreement, 0.21 to 0.40 fair, 0.41 to 0.60 moderate, 0.61 to 0.80 substantial, and 0.8 to 1.00 almost perfect agreement (Landis & Koch 1977). Global percentage of agreement refers to the agreement between responses between the first and second test occasions, indicating the percentage of responses that remained in the same category on both measurement occasions.

In study II, differences in the study variables were tested using Student's t-test and Pearson's chi-squared test. Multinomial logistic regression analysis was used to investigate the associations between the prevalence of NSP and accelerometer-measured MVPA or ST. The NSP prevalence was treated as a dependent variable and objectively measured MVPA/ST as an independent variable. Groups a) NSP at least once a week and b) NSP about once a month were compared with group c) NSP rarely or never experienced, which was used as the reference category for modeling. The significance of interaction term was tested (three-way interaction gender×age×MVPA/ST and all lower order terms were included in the model) to determine the association differences between gender and age. In addition, the model was adjusted for BMI, bedtime, and injuries (1 = traumatic pain in the spinal region, 0 = no traumatic pain in the spinal region). Simple slopes of association between MVPA/ST and NSP were examined when a significant interaction was found.

In study III, the variables at three measurement points (baseline (T0), 1-year follow-up (T1), and 2-year follow-up (T2)) were studied. MVPA and ST (ST10min) were used as absolute values min/day. For children who reported NSP less than once a week at baseline and T1, the NSP incidence variable was assigned a value of 0 (this was the reference category), and if NSP was reported higher than the reference category at T1, the NSP incidence variable was assigned a value of 1. Reported NSP at least once a week already at T0 was not included in the analysis. Logistic regression analysis was used to study the NSP incidence in the different independent variables, and the models were adjusted for age, gender, spinal area injuries (upper or lower back, n=81), BMI, and bedtime (23.00 or later).

In study IV, the Move! results at baseline (T0) and one-year measurement point (T1) were used, and the self-reported weekly NSP at three measurement points (T0, T1, and T2) was analyzed. NSP incidence was calculated between T0 and -T2 and between T0 and -T1 and T1 and -T2. The scores for the physical fitness characteristics of the Move! measurements were classified into three categories for the logistic regression analysis. The categories were good (tertile

3), moderate (tertile 2), and low (tertile 1). The tertiles were uniform in size as possible and standardized by age and gender to prevent weighted results. Both unadjusted (model 1) and adjusted models to age, gender, and BMI (model 2) were analyzed. Tertile 1 was the reference category. Tertiles were not necessary in the flexibility measurement analysis, as the variable was already dichotomous (failed/succeeded). Failed performance was then the reference category.

5 RESULTS

The results are presented by each research question, beginning with a description of the sample. First, the results related to the repeatability of the pain questionnaire were presented. Second, the associations of PA or ST to school-aged children´s NSP were addressed. Third, the associations of MVPA, ST, and self-reported physically passive screen time, and physical fitness characteristics with the NSP incidence were reported.

5.1 Description of the populations

In study I, from a total of 206 children from grades 4 to 9 who were invited into the study, 83% (n=181) filled in questionnaires twice and were included in the analysis of the study (Table 3). Of 77 primary school children (grades 4 to 6), 41 were boys, and 36 were girls. Lower secondary school children (grades 7 to 9) were 104 of which 40 were boys, and 64 were girls. Of the pain symptoms observed, the highest prevalence of pain was found in the head (29%) and NS (23%) (Table 3). In both the head and NS areas, the prevalence of pain was more than twice as high in lower secondary school children (37% and 30%, respectively) than in primary school students (16% and 13%, respectively).

TABLE 3 Pain prevalence according to body areas experienced at least once a week during the first survey for all and separately for children in primary and lower secondary schools.

Pain area	**All (n=181) N (%)**	**Primary school (Grades 4-6, n=77) N (%)**	**Secondary school (Grades 7-9, n=104) N (%)**
Head	60 (29)	13 (16)	47 (37)
Neck and shoulder	48 (23)	10 (13)	38 (30)
Upper extremities	17 (8)	4 (5)	13 (10)
Chest	12 (6)	3 (4)	9 (7)
Upper back	26 (13)	8 (10)	18 (14)
Lower back	27 (13)	9 (11)	18 (14)
Stomach	25 (12)	7 (9)	18 (14)
Buttocks	17 (8)	6 (8)	11 (9)
Lower extremities	26 (13)	7 (9)	19 (15)

Participants (N=970) in studies II, III, and IV were 12.6 ($\pm$1.3, boys) and 12.5 ($\pm$1.3, girls) years old at baseline (Table 4). The mean BMI was 18.6 $kg{\cdot}m^{-2}$ for the boys and 19.1 $kg{\cdot}m^{-2}$ for the girls. No significant difference was noted between the genders in the bedtime; approximately 5.7% of children went to bed late (later than 23:00.)

Of the accelerometer wearing time, mean MVPA was 59.2 min for boys and 47.5 min for girls per day at baseline. ST was accumulated for 3.5 h per day for boys and 3.8 h per day for girls of the total accelerometer wearing time at baseline. At T2, mean MVPA among all children was 7.5 minutes less and mean ST was approximately 1 h more at baseline.

Self-reported physically passive screen time was 4.5 h per day for boys and 4.0 h per day for girls at baseline (Table 4). At T2, the screen time was approximately 5 h for all. Table 5 shows the numbers of boys and girls in the measurements of different physical fitness characteristics, average performances and differences between boys and girls in these measurements. All the physical fitness characteristics combined differed between boys and girls (p=0.008–<0.001), although the starting position in the push-up and throwing–catching combination tests were adjusted by gender and age (Table 5).

TABLE 4 Descriptive table of the study populations in studies II, III, and IV.

	Measurement point	All Mean (SD)	N	Boys Mean (SD)	N	Girls Mean (SD)	N	*p*
Age (years)	T0	12.5 (1.3)	970	12.6 (1.3)	462	12.5 (1.3)	508	0.605
BMI (kg/m2)	T0	18.9 (3.2)	914	18.6 (3.3)	429	19.1 (3.2)	485	0.054
Bedtime 23.00 or later, n (%)	T0	54 (5.7)	947	24 (5.3)	451	30 (6.0)	496	0.630
Injury at spinal area, n (%)	T0	81 (8.6)	947	45 (10.0)	451	36(7.3)	496	0.135
NSP (at least once a week)	T0	26%	905	23%	430	28%	475	0.091
NSP incidence	T0–T1	15%	605	11%	294	19%	311	0.006
NSP incidence	T1–T2	18%	586	16%	295	20%	291	0.207
NECK AND SHOULDER PAIN								
NSP total, range 1–5*	T0	2.0 (1.1)	905	1.9 (1.0)	430	2.0 (1.1)	475	0.110
	T1	1.8 (1.0)	847	1.7 (0.9)	400	2.0 (1.1)	447	<0.001
	T2	1.9 (1.1)	780	1.8 (1.0)	369	2.1 (1.1)	411	<0.001
NSP (at least once a week), n (%)	T0	235 (26)	905	99 (23)	430	133 (28)	475	0.091
	T1	195 (23)	847	68 (17)	400	125 (28)	447	<0.001
	T2	211 (27)	780	78 (21)	369	127 (31)	411	0.001
NSP incidence, n (%)	T0–T1	91 (15)	605	32 (11)	294	59 (19)	311	0.006
	T1–T2	105 (18)	586	47 (16)	295	58 (20)	291	0.207
ACCELEROMETER-MEASUREMENTS								
MVPA (min/day)	T0	52.7 (21.7)	767	59.2 (23.7)	342	47.5 (18.4)	425	<0.001
	T1	51.5 (22.6)	503	57.8 (25.0)	209	47.1 (19.5)	294	<0.001
	T2	45.2 (19.1)	319	47.1 (19.8)	127	43.9 (18.5)	192	0.145
< 60 min/d, %	T2	66.2	319	75.8	127	54.1	192	0.135
≥ 60 min/d, %	T2	33.8	319	45.9	127	24.2	192	<0.001

continues

TABLE 4 continues

	Measurement point	All Mean (SD)	N	Boys Mean (SD)	N	Girls Mean (SD)	N	*p*
ST10min (h/day)	T0	3.7 (1.2)	767	3.5 (1.3)	342	3.8 (1.2)	425	0.003
	T1	4.1 (1.3)	503	3.9 (1.3)	209	4.3 (1.3)	294	0.007
	T2	4.8 (1.4)	319	4.8 (1.4)	127	4.8 (1.3)	192	0.817
SELF-REPORTED SCREEN TIME Screen time (h/day)								
	T0	4.2 (2.8)	948	4.5 (3.1)	451	4.0 (2.5)	497	0.002
	T1	4.7 (3.0)	868	5.2 (3.2)	411	4.3 (2.7)	457	<0.001
	T2	5.0 (3.1)	798	5.4 (3.1)	381	4.6 (3.1)	417	<0.001
TV time (h/day)	T0	1.8 (1.2)	948	1.9 (1.2)	451	1.7 (1.1)	497	0.088
	T1	1.9 (1.3)	868	2.1 (1.3)	411	1.8 (1.2)	457	0.002
	T2	2.0 (1.3)	798	2.1 (1.3)	381	1.9 (1.2)	417	0.020
Games (h/day)	T0	1.3 (1.3)	948	1.8 (1.4)	451	1.0 (1.0)	497	<0.001
	T1	1.2 (1.3)	868	1.8 (1.5)	411	0.7 (0.9)	457	<0.001
	T2	1.2 (1.5)	798	2.0 (1.6)	381	0.5 (1.0)	417	<0.001
Social media (h/day)	T0	1.1 (1.2)	948	0.9 (1.2)	451	1.3 (1.3)	497	<0.001
	T1	1.6 (1.6)	868	1.3 (1.5)	411	1.8 (1.7)	457	<0.001
	T2	1.8 (1.7)	798	1.3 (1.5)	381	2.3 (1.8)	417	<0.001

BMI=Body mass index; NSP=neck and shoulder pain, NSP total, range 1–5*, response options: 1=rare or never, 2=approximately once a month, 3=once a week, 4=more than once a week, 5=almost daily; MVPA=moderate-to-vigorous physical activity; ST10min = absolute accelerometer wear-time in which at least 10 min was sedentary (<100 counts per minute); p-value for gender difference (Student's t-test or Pearson's chi-squared test).

TABLE 5 Participants in the measurements of physical fitness characteristics for all and for boys and girls separately, and differences between boys and girls in measurements in different grades

	Grade	All N	Mean (SD)	Boys N	Mean (SD)	Girls N	Mean (SD)	*p* (boys/ girls)
Squat	4	207	89%	98	86%	109	92%	0.168
	5	157	94%	63	92%	94	95%	0.510
	6	164	92%	89	89%	75	96%	0.087
	7	382	92%	179	89%	203	94%	0.138
	TOT	910	91%	429	89%	481	94%	0.008
Lower back extension	4	207	72%	98	62%	109	82%	0.002
	5	157	80%	63	67%	94	88%	0.001
	6	164	79%	89	72%	75	87%	0.022
	7	382	81%	179	75%	203	87%	0.005
	TOT	910	79%	429	70%	481	86%	<0.001

continues

TABLE 5 continues

	Grade	All N	Mean (SD)	Boys N	Mean (SD)	Girls N	Mean (SD)	*p* (boys/ girls)
Shoulder strech/Right	4	207	88%	98	95%	109	82%	0.003
	5	157	89%	63	92%	94	86%	0.256
	6	164	93%	89	92%	75	95%	0.518
	7	381	89%	179	92%	202	86%	0.091
	TOT	909	89%	429	93%	480	86%	0.003
Shoulder strech/Left	4	207	59%	98	53%	109	64%	0.103
	5	157	66%	63	60%	94	69%	0.254
	6	164	60%	89	49%	75	72%	0.003
	7	382	69%	179	54%	203	82%	<0.001
	TOT	910	64%	429	54%	481	74%	<0.001
Push-up (repetitions)	4	197	16.6 (12.7)	96	13.1 (12.4)	101	19.9 (12.1)	<0.001
	5	155	19.5 (12.6)	62	13.9 (9.6)	93	23.2 (13.1)	<0.001
	6	158	19.3 (11.0)	83	17.0 (11.5)	75	21.7 (9.9)	0.007
	7	367	23.5 (13.5)	172	19.5 (11.5)	195	27.1 (14.2)	<0.001
	TOT	877	20.5 (13.0)	413	16.7 (11.7)	464	23.9 (13.2)	<0.001
Curl-up (repetitions)	4	205	29.8 (19.0)	97	29.2 (19.2)	108	30.4 (18.9)	0.637
	5	157	41.3 (21.9)	63	41.6 (22.3)	94	41.2 (21.9)	0.910
	6	161	41.4 (20.8)	88	42.6 (20.8)	73	39.8 (20.7)	0.391
	7	373	37.2 (19.6)	177	42.8 (19.8)	196	32.1 (18.0)	<0.001
	TOT	896	37.0 (20.5)	425	39.5 (21.0)	471	34.7 (19.9)	<0.001
Throwing-catching combination (repetitions)	4	206	9.5 (4.8)	98	10.3 (4.9)	108	8.8 (4.6)	0.030
	5	156	12.1 (5.4)	63	13.4 (5.4)	93	11.2 (5.2)	0.009
	6	164	14.1 (4.5)	89	14.6 (4.8)	75	13.5 (4.1)	0.128
	7	375	12.4 (4.4)	177	12.6 (4.5)	198	12.3 (4.2)	0.495
	TOT	901	12.0 (4.9)	427	12.6 (5.0)	474	11.5 (4.8)	<0.001
5-leap (m)	4	204	7.4 (0.9)	97	7.5 (0.9)	107	7.4 (0.9)	0.463
	5	154	7.9 (1.0)	63	8.2 (0.9)	91	7.7 (1.0)	0.003
	6	157	8.2 (1.0)	83	8.4 (1.1)	74	8.1 (0.8)	0.089
	7	367	8.8 (1.1)	173	9.2 (1.1)	194	8.4 (0.9)	<0.001
	TOT	882	8.2 (1.1)	416	8.5 (1.2)	466	8.0 (1.0)	<0.001
20-m shuttle run (laps)	4	206	34.7 (16.3)	98	37.6 (17.6)	108	32.1 (14.6)	0.015
	5	152	40.3 (17.6)	63	47.5 (18.4)	89	35.3 (15.1)	<0.001
	6	158	42.4 (19.8)	84	47.3 (22.3)	74	36.9 (14.7)	<0.001
	7	355	46.5 (19.1)	165	53.4 (19.4)	190	40.6 (16.7)	<0.001
	TOT	871	41.9 (18.9)	410	47.5 (20.3)	461	37.0 (15.9)	<0.001

5.2 Prevalence and incidence of NSP

The mean prevalence of NSP at least once a week was 26% among all children (II, III, IV). No difference between boys and girls was observed in the NSP prevalence. Figure 5 presents the distribution of the NSP prevalence at all the three measurement points. Mean NSP incidence was 15% between T0 and -T1 and 18% between T1 and -T2 (Figure 6). Figure 6 shows the distribution of NSP incidence in boys and girls and all children together between the grades. The incidence of NSP was lowest among 6th grade boys (6%) between T1 and -T2 and highest in 7th grade girls (28%) between T0 and -T1. Among all children, 8th grade children had the highest incidence of NSP at 23% (Figure 6).

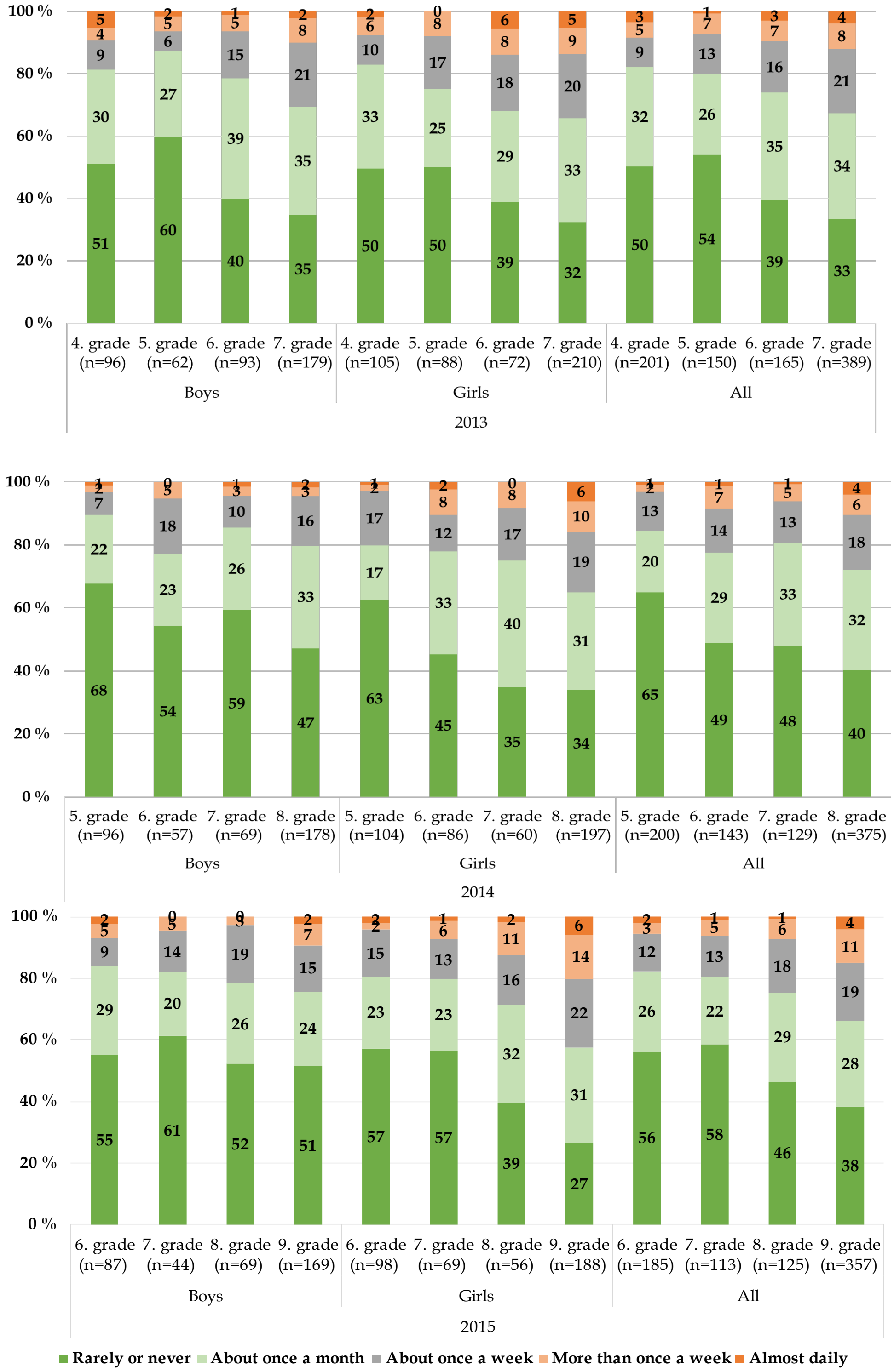

FIGURE 5 Prevalence of neck and shoulder pain (NSP) at baseline 2013 (T0), 1-year measurement point (T1), and 2-year measurement point (T2).

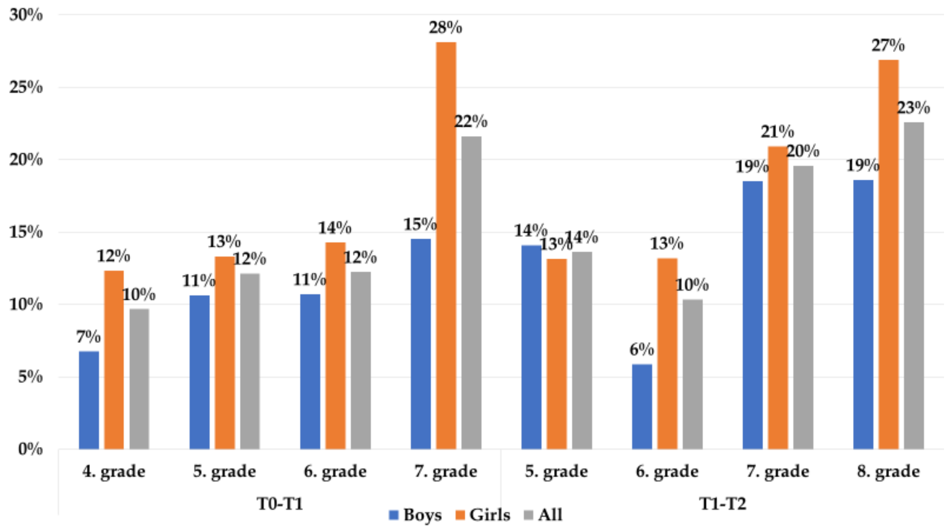

FIGURE 6 Neck and shoulder pain (NSP) incidence in boys, girls, and all participants in the first (T0–T1) and second (T1–T2) follow-up year.

5.3 Repeatability of the pain questionnaire (I)

Table 6 shows the repeatability of the pain questionnaire. The NS, head and lower extremities had good repeatability among all children (ICC 0.67, 0.66 and 0.62, respectively) when questions concerning pain were analyzed using the five-point scale. In primary school children, the ICC for the lower extremities (ICC 0.70) was good, and for NS (0.59), the lower back (0.58), and the head (0.56), the ICC was fair. Other questions' repeatability was poor (ICC<0.40). The ICCs for pain in the NS and head were good (0.70, 0.69), and the stomach (0.59) and lower extremities (0.57) were fair in the analysis of the lower secondary school children. The other pain areas remained with poor repeatability.

The pain in the head (0.70) and NS (0.68) had substantial repeatability in all children and the agreement percentage varied between 88% and –94% when the results were analyzed using the two-point scale and kappa [κ] coefficient. Among primary school children, four pain area questions had acceptable repeatability with substantial kappa-values; the lower extremities (0.79), NS (0.67), lower back (0.67), and head (0.66). The questions on other pain area had moderate repeatability, except that question concerning pain in the upper extremities, which had fair repeatability (0.30). Among lower secondary school children, questions concerning pain in the head (0.69) and NS (0.67) had substantial repeatability, and questions for the lower extremities (0.52), stomach (0.47), and upper extremities (0.45) had moderate repeatability. For all the pain sites, primary and secondary school agreement percentages varied between 92% and –98% and 83% and –92%, respectively.

TABLE 6 Test–retest repeatability of the pain questions measured 2 weeks apart in all children, and separately for children in primary and lower secondary schools.

Pain area	N	Trauma N	5-Point scale ICC (95% CI)	2-Point scale Kappa (95% CI)	2-Point scale Agreement (% same)
All					
Head	161	20	0.66 (0.56–0.74)	0.70 (0.58–0.83)	88
Neck and shoulder	168	13	0.67 (0.58–0.75)	0.68 (0.55–0.82)	89
Upper extremities	146	35	0.36 (0.21–0.50)	0.41 (0.14–0.68)	92
Chest	177	4	0.36 (0.23–0.48)	0.35 (0.03–0.66)	94
Upper back	170	11	0.40 (0.26–0.52)	0.33 (0.10–0.56)	89
Lower back	167	14	0.40 (0.26–0.52)	0.36 (0.15–0.58)	87
Stomach	174	7	0.49 (0.37–0.59)	0.44 (0.23–0.66)	90
Buttocks	173	8	0.38 (0.25–0.50)	0.21 (-0.03–0.46)	90
Lower extremities	109	72	0.62 (0.48–0.72)	0.60 (0.33–0.87)	94
Primary school					
Head	64	13	0.56 (0.36–0.71)	0.66 (0.39–0.93)	92
Neck and shoulder	71	6	0.59 (0.42–0.72)	0.67 (0.40–0.94)	93
Upper extremities	56	21	0.21(-0.05–0.45)	0.30 (-0.21–0.80)	93
Chest	74	3	0.28 (0.06–0.48)	0.49 (-0.13–1.10)	97
Upper back	71	6	0.38 (0.16–0.56)	0.47 (0.03–0.91)	94
Lower back	73	4	0.58 (0.40–0.71)	0.67 (0.40–0.94)	93
Stomach	73	4	0.30 (0.08–0.49)	0.36 (-0.04–0.76)	92
Buttocks	73	4	0.44 (0.24–0.61)	0.47 (0.03–0.91)	95
Lower extremities	43	34	0.70 (0.51–0.83)	0.79 (0.39–1.19)	98
Lower secondary school					
Head	97	7	0.69 (0.57–0.78)	0.69 (0.54–0.84)	86
Neck and shoulder	97	7	0.70 (0.58–0.79)	0.67 (0.51–0.83)	87
Upper extremities	90	14	0.39 (0.20–0.55)	0.45 (0.13–0.77)	91
Chest	103	1	0.37 (0.19–0.52)	0.29 (-0.07–0.65)	92
Upper back	99	5	0.39 (0.21–0.55)	0.26 (-0.01–0.53)	85
Lower back	94	10	0.23 (0.03–0.41)	0.11 (-0.14–0.36)	83
Stomach	101	3	0.59 (0.44–0.70)	0.47 (0.22–0.73)	88
Buttocks	100	4	0.36 (0.18–0.52)	0.07 (-0.17–0.31)	87
Lower extremities	66	38	0.57 (0.38–0.71)	0.52 (0.18–0.86)	91

Note. Trauma cases are included in reported pain in the first, second, or both studies.

5.4 Cross-sectional associations of physical activity and sedentary time (II)

A gender difference (p=0.020) was found when the association between MVPA and NSP at least once a week was studied (II). Among boys, higher MVPA time was associated with lower probability of NSP; however, the association was not observed among girls (boys, p=0.031, girls, p=0.230) (Figure 7). The odds ratios (OR) for NSP at least once a week were 1.5% lower per every minute more of MVPA (OR=0.99). Boys who had 30 min or more of MVPA had 36% lower odds for experiencing NSP at least once a week (OR=0.64) than boys, who accumulated less MVPA than 30 min. When NSP was experienced once a month, no association to MVPA was found. The regression coefficient for interaction term gender x age x MVPA was not significant in the model of NSP experienced at least once a week (b=-0.005, se=0.008, p=0.530) or NSP experienced once a month (b=-0.003, se=0.007, p=0.710) and was not therefore included in the final model. No association was found between ST and NSP experienced at least once a week (Figure 8).

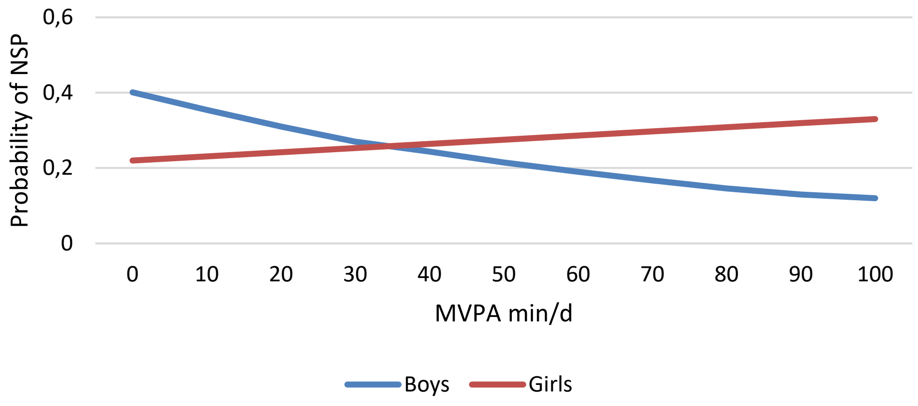

FIGURE 7 Statistically significant association between moderate-to-vigorous physical activity (MVPA) and neck and shoulder pain (NSP) at least once a week in boys and girls (II).

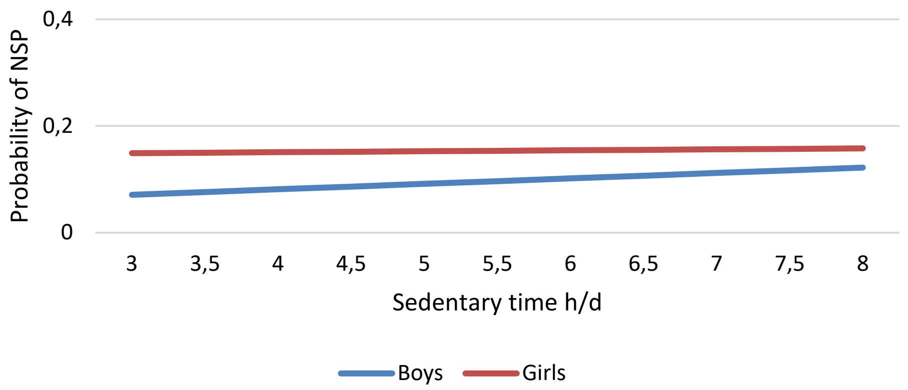

FIGURE 8 Relationship between sedentary time (ST) and neck and shoulder pain (NSP) at least once a week in boys and girls (II). No statistical significance.

5.5 Longitudinal associations of physical activity and screen time (III)

At baseline, a total of 767 of the studied children participated in PA monitoring using accelerometers. Of these children, 503 participated in accelerometer-measurements in the 1-year measurement point (T1). Accelerometer-measured MVPA or ST was not associated with the NSP incidence in T0–T1 or T1–T2. Self-reported physically passive screen time was analyzed as the total screen time use and separately for TV-viewing, physically passive gaming time, and social media time. In T0–T1, the interaction of total screen time and age with NSP incidence was significant (b=-1.85, se=0.83, p=0.027) but not in T1–T2 (b=0.76, se=0.66, p=0.254). An association was found between total screen time use (p=0.020) (Figure 9), physically passive gaming time (p=0.036) (Figure 10), social media time (p=0.023) (Figure 11), and NSP incidence between T0 and T1, but not between T1 and T2 (p=0.272, p=0.226, and p=0.630, respectively).

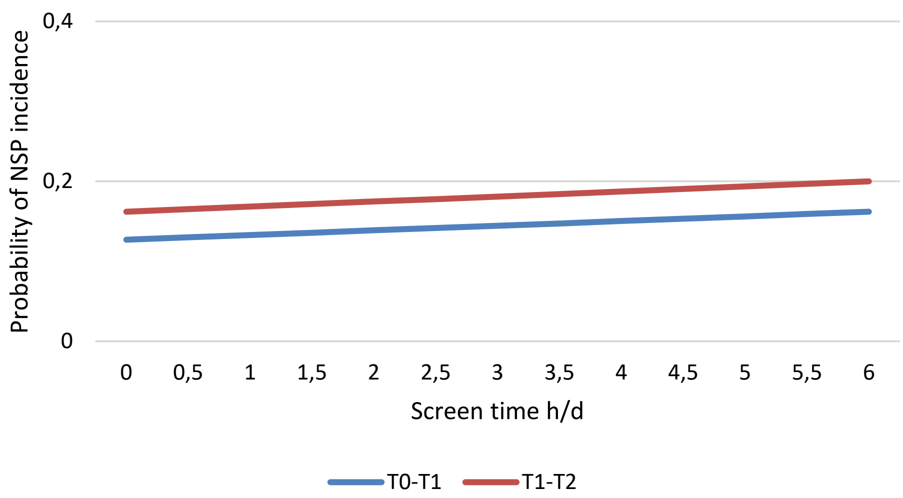

FIGURE 9 Interaction between physically passive screen time (h/day) and probability of neck and shoulder pain (NSP) incidence (at least once a week) (III). Note. The predicted probabilities were calculated based on the parameters of the logistic regression model. NSP "rare or never" was the reference category. The model was controlled for age, body mass index, bedtime, and injuries in the spinal area.

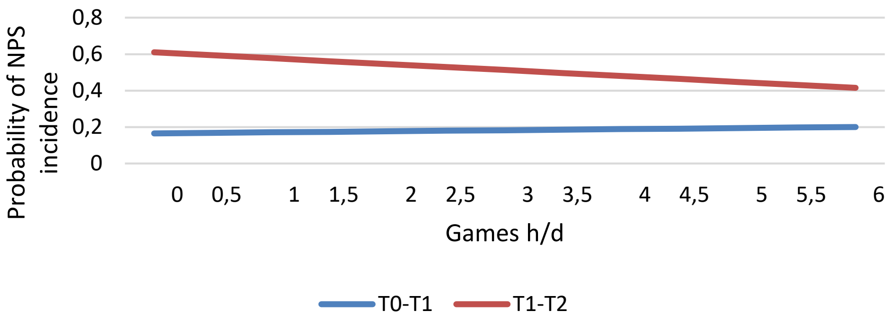

FIGURE 10 Interaction between physically passive gaming time (h/day) and probability of neck and shoulder pain (NSP) incidence (at least once a week) (III). Note. The predicted probabilities were calculated based on the parameters of the logistic regression model. NSP "rare or never" was the reference category. The model was controlled for age, body mass index, bedtime, and injuries in the spinal area.

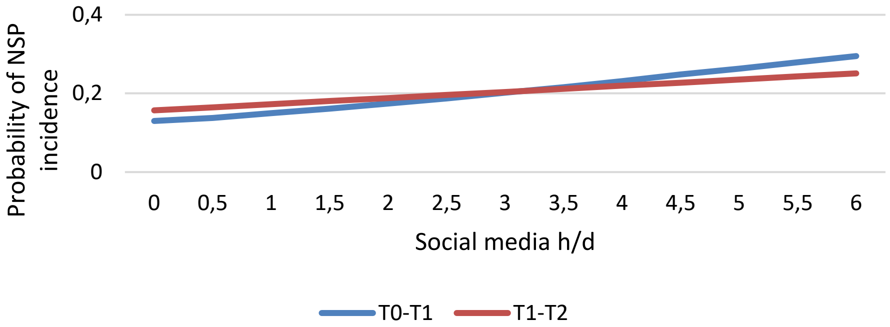

FIGURE 11 Interaction between social media time (h/day) and probability of neck and shoulder pain (NSP) incidence (at least once a week) (III). Note. The predicted probabilities were calculated based on the parameters of the logistic regression model. NSP "rare or never" was the reference category. The model was controlled for age, body mass index, bedtime, and injuries in the spinal area.

5.6 Longitudinal associations of physical fitness (IV)

Table 7 presents the associations between the NSP incidence and flexibility outcomes (failed/succeeded) in the unadjusted and adjusted (age, gender, and BMI) models at the three follow-ups (T0–T2, T0–T1, and T1–T2). Successful, but not failed, lower back extension was associated with a higher NSP incidence (OR=3.30) between T0 and T2. The association remained significant after adjustment (OR=2.83). No other marked associations between the other flexibility measurements and the NSP incidence were found between the two-year follow-up time (T0 and T2) or between T0 and T1 or T1 and T2.

TABLE 7 Logistic regression analysis between flexibility and neck and shoulder pain incidence in school-aged children during the 2- (T0–T2) and 1-year follow-ups (T0–T1, T1–T2).

Measure-ment			T0–T2		T0–T1		T1–T2	
			Model 1	**Model 2**	**Model 1**	**Model 2**	**Model 1**	**Model 2**
		No	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Lower back extension	OR	1	3.30	2.83	1.56	1.30	1.74	1.65
	95% CI	1	1.49–7.28	1.28–6.25	0.66–3.68	0.58–2.90	0.86–3.54	0.81–3.34
	p	-	**0.003**	**0.010**	0.308	0.524	0.125	0.166
Squat	OR	1	2.48	2.05	0.72	0.55	1.27	1.20
	95% CI	1	0.82–7.52	0.68–6.21	0.34–1.51	0.27–1.13	0.37–4.33	0.34–4.22
	p	-	0.107	0.204	0.384	0.103	0.701	0.781
Right shoulder stretch	OR	1	1.43	1.65	1.43	1.63	1.79	1.84
	95% CI	1	0.59–3.44	0.67–4.09	0.58–3.51	0.70–3.80	0.80–3.99	0.81–4.16
	p	-	0.431	0.279	0.436	0.254	0.155	0.143
Left shoulder stretch	OR	1	1.36	1.18	0.95	0.83	1.07	0.99
	95% CI	1	0.79–2.36	0.68–2.05	0.53–1.70	0.48–1.43	0.65–1.77	0.58–1.69
	p	-	0.267	0.560	0.864	0.499	0.795	0.962

Model 1=crude analysis, Model 2=adjusted with age, gender, and BMI (body mass index). No=failed, Yes=succeeded. T0=baseline, T1=first follow-up year, T2=second follow-up year. Statistically significant results are marked in bold.

Table 8 shows the associations of muscular fitness, fundamental movement skills, and cardiorespiratory fitness with NSP incidence at the three follow-ups. The children with good curl-up scores (tertile 3) had a higher risk for NSP incidence in the unadjusted and adjusted model (OR=1.75 and OR=1.80, respectively) compared with the children with low scores (tertile 1) between T0 and T2. In the throwing–catching combination test, the children in tertile 3 were less likely to have NSP between T0 and T2 (unadjusted model, OR=0.55) than those in tertile 1. However, this association disappeared after adjustments of the model. No other marked associations between these physical fitness characteristics and NSP incidence were found at either follow-up.

TABLE 8 Logistic regression analysis between muscular fitness, fundamental movement skills, cardiorespiratory fitness measurements, and NSP incidence in school-aged children during the 2-year follow-up (T0–T2) and 1-year follow-ups (T0–T1, T1–T2).

			T0-T2 Model 1		**Model 2**		**T0-T1 Model 1**		**Model 2**		**T1-T2 Model 1**		**Model 2**	
		Ter1	**Ter2**	**Ter3**	**Ter2**	**Ter3**	**Ter2**	**Ter3**	**Ter2**	**Ter3**	**Ter2**	**Ter3**	**Ter2**	**Ter3**
Push-up	OR	1	1.33	1.52	1.33	1.60	1.37	1.20	1.39	1.25	1.43	1.19	1.39	1.09
	95% CI	1	0.76–2.32	0.78–2.98	0.70–2.53	0.79–3.24	0.75–2.50	0.67–2.17	0.70–2.76	0.66–2.36	0.77–2.67	0.64–2.21	0.71–2.74	0.57–2.10
	p	-	0.320	0.219	0.377	0.190	0.300	0.541	0.343	0.492	0.258	0.587	0.339	0.788
Curl-up	OR	1	1.19	1.75	1.24	1.80	0.73	1.46	0.79	1.47	1.31	1.33	1.21	1.20
	95% CI	1	0.66–2.16	1.01–3.04	0.65–2.35	1.02–3.16	0.36–1.45	0.76–2.79	0.40–1.56	0.77–2.83	0.745–2.31	0.73–2.43	0.68–2.16	0.63–2.29
	p	-	0.569	**0.048**	0.511	**0.042**	0.365	0.255	0.494	0.246	0.341	0.358	0.508	0.573
Thro-wing-cat-ching	OR	1	1.06	0.55	1.09	0.59	1.13	0.68	1.19	0.75	0.97	0.85	0.97	0.89
	95% CI	1	0.65–1.73	0.31–0.97	0.66–1.82	0.34–1.03	0.63–2.02	0.35–1.31	0.67–2.12	0.39–1.42	0.57–1.68	0.49–1.46	0.55–1.72	0.52–1.53
	p	-	0.822	**0.038**	0.729	0.065	0.675	0.244	0.544	0.372	0.925	0.547	0.921	0.676
5-leap	OR	1	1.13	1.00	1.14	1.05	0.84	0.92	0.85	0.97	0.79	0.71	0.76	0.68
	95% CI	1	0.66–1.91	0.59–1.71	0.64–2.02	0.61–1.82	0.44–1.60	0.53–1.61	0.41–1.74	0.53–1.77	0.48–1.30	0.38–1.33	0.46–1.24	0.36–1.29
	p	-	0.662	0.994	0.656	0.853	0.600	0.776	0.648	0.925	0.350	0.279	0.269	0.239
Shutt-le-run	OR	1	1.56	1.08	1.53	1.11	1.47	0.81	1.46	0.76	1.28	1.15	1.18	1.06
	95% CI	1	0.83–2.94	0.60–1.95	0.79–2.98	0.60–2.07	0.74–2.89	0.40–1.67	0.73–2.93	0.36–1.63	0.68–2.41	0.55–2.39	0.63–2.22	0.50–2.23
	p	-	0.171	0.791	0.209	0.736	0.269	0.570	0.290	0.484	0.444	0.708	0.610	0.884

Model 1=crude analysis, Model 2=adjusted with age, gender, and BMI (body mass index). T0=baseline, T1=first follow-up year, T2=second follow-up year. Ter1=Tertile 1 (reference category)/low scores. Ter2=Tertile 2/moderate scores. Ter3=Tertile 3/high scores. OR=odds ratio, CI=confidence interval. Statistically significant results are marked in bold.

6 DISCUSSION

The purpose of the present dissertation was to evaluate the test–retest reliability of the web-based pain questionnaire used and examine the associations of MVPA, ST, physically passive screen time, and physical fitness characteristics of NSP prevalence or incidence in school-aged, 10- to 15-year-old children. First, the chapter examines the results of this dissertation in relation to previous literature. Second, the strengths and limitations are discussed. Finally, conclusions are presented for the results and practical implications, and future research needs related to the topic are discussed.

6.1 Questionnaire as a method

In study I, the test–retest reliability of pain-related questions of the web-based questionnaire in Finnish 10- to 15-year-old school-aged children were evaluated, and the prevalence of pain in different pain areas was investigated. One third of the children, on average, reported headache and a quarter reported pain in the neck and shoulder area during the last 3 months before filling up the questionnaire. Overall, the children in the lower secondary school had higher frequencies of pain than the children in primary school. The frequencies of headache and NSP were almost three times higher in lower secondary school children than among the children in primary school. A previous cohort study reported similarly that the prevalence of weekly experienced NSP was more common in older age groups (14-, 16-, and 18-year-old children) than in 12-year-old children (Hakala et al., 2002).

The most repeatable questions among all the children, were the questions concerning pain in the NS area and head among all the pain sites using either a five-point (ICC 0.67 and 0.66) or two-point scale (kappa [κ] 0.68 and 0.70) in the analysis. However, the prevalence affecting kappa values (Watson & Petrie, 2010) is noteworthy. The higher kappa values in most frequent pain localizations can be partly explained because of this phenomenon. Therefore, kappa values should be critically compared between different studies, as the variability of the prevalence of pain might be large.

The recall time, along with time between measures and age, can be considered important, particularly when comparing results in studies in growing children. Hakala et al. (2002) reported slightly lower kappa values (0.48–0.67) than those reported in the current dissertation (study I), in their test–retest study for back and NP repeatability. However, pain was asked for during the last 6 months in that study, and retesting was performed every 4–6 weeks for three different years. In a Brazilian study, the test–retest reliability of a questionnaire with a 10-day interval to be substantial with a Kappa value of 0.72 (Jannini et al., 2011). The respondents in that study included adolescents with a wide age range of 10–19. They were asked about the experienced pain symptoms during the past 3 months concerning the overall musculoskeletal symptoms (Jannini et al., 2011). A very long recall period, "current school year," was used in a study evaluating the internal consistency of an American pilot study for seventh and eighth graders concerning the back pain and NP questions in the study. The result was reported as moderate with kappa value of 0.54 (Mehta et al., 2002). The kinds of differences in the above-mentioned study settings affect a successful comparison with this study results. Fragmented research data may affect perceptions and understanding of the repeatability of pain questionnaires to some extent in children's pain studies.

A relatively small sample might be the weakness of study I; however, the study has many strengths. The response rate was high in both age groups, as the data was collected during school days in classrooms, probably effecting positively on the number of responses. Missing values were largely avoided, as the web-based system did not allow to proceed further if the answer was left empty. The time interval between two data collection points was accurate considering the age of the population. Children were also free from their parents' opinions in the answering situation, as the questionnaire was filled in the school environment during school days. The situation was not a social event; thus, the children could consider their answers in peace. As pain is a subjective experience, asking the children themselves about pain is justified, and questionnaires can be used to reach a large group of subjects as much as possible. The web-based pain questionnaire used, proved to be an acceptable method for examining pain in children aged 10–15 years and is therefore a recommended tool for collecting NSP information in school-aged children.

6.2 Neck and shoulder pain and the role of physical activity and sedentary time

In study II, the NSP prevalence of the children was approximately 26% with no gender differences. This is more than a quarter of the children and compared with that of the Husu et al. (2016) study in 10- to -14-year-old children, who experienced, on average, 7% (boys) and 14% (girls) at least weekly NSP, this result is higher. Comparing the incidence values with other studies is difficult owing to the different research settings of the longitudinal studies and the small number of NSP studies. The novelty in this dissertation was the focus on the true non-cumulative NSP incidence in children followed up for 2 years and the investigation of the factors associated with it in two different original studies.

NSP incidence in children has been investigated according to very different definitions in studies, for example, neck and upper limb pain occurring at least once a week in the preceding 6 months (cumulative annual incidence 28%) (Ehrmann Feldman et al., 2002), 6 months of incidence of NSP in any frequency in 15- to –18-year-olds to adulthood (17 to 28%) (Siivola et al., 2004), pain occurring in eight or more days during the past year among 11- to 14- and among 22-year-olds (lifetime cumulative incidence of NP 78% in 78% in females, 58% in males) (Poussa et al., 2005), and the incidence of any UQMP during the preceding month after 6 and 12 months from baseline in 15–17-year-olds (34.2% with UQMP) (Brink et al., 2009). All the above-mentioned studies examined approximately the same pain area; however, in the study of Poussa et al. (2005), the studied NP area was not detailed. El-Metwally et al. (2007) defined the incidence of pain in a similar way it has been defined in this study and reported a 19% incidence in overall musculoskeletal pain, from which, on average, 10% was reported to be NP incidence, in children aged approximately 11 years. Compared with this study (III) and the observed incidence of 15% in the first follow-up year and 18% in the second follow-up year, the study of El-Metwally et al. (2007) could be the most comparable study. However, the current population was drawn from all parts of Finland, whereas the population in the El-Metwally et al. (2007) study was from the same city in southern Finland. The population in this study was also slightly older. A greater incidence of NSP than in this study (III) was reported by Aartun et al. (2014) with 60% (95% CI: 54.1, 66.0) incidence in 11- to 13-year-old children during the 2-year period; however, all new cases during the 2-year follow-up were included cumulatively. In this study, only weekly NSP incidences from the last 3 months per yearly measurement point were included.

Future studies should use the best available information in the definitions of prevalence and incidence to investigate the true non-cumulative incidence of pain condition in school-aged children to compare estimates of the prevalence and incidence of NSP between different studies. This addresses also the understanding of the reported nature of children's fluctuating NSP (Ståhl et al., 2008). Thus, the data collection methods should be more unified when comparable information about children's NSP situation is aimed to be collected.

The amount of PA (II) was the lowest for girls; only 24% of them were physically active during the recommended 60 min on the MVPA level, while 46% of the boys accumulated the recommended amount of MVPA. On average, 34% of the subjects achieved the 60 min recommended amount of MVPA daily. This result is in line with a recently published FSPA (the Finnish School-age Physical Activity) 2016 report, where a total of 3274 participants (3rd, 5th, 7th, 9th grades) were studied and observed, and on average, one third of the children (31.3%) met the PA recommendation (Jussila et al., 2022). Compared with the International Children's Accelerometry Database (ICAD), in which the measurements of Finnish children have not been considered (Cooper et al., 2015), the mean MVPA (52.7 min/day) of this study population was in line with international levels of children in the same age by a mean PA of 51.6 min/day (Brazendale et al., 2021). Compared with European data (62.3 min/day) only (Brazendale et al., 2021), the share of daily MVPA was approximately 10 min less in this study population. Both total PA and percentage of MVPA gradually decrease in each age group after 5–6 years, and this corresponds, on average, 4.2% annual decrease in total PA (Cooper et al., 2015). Simultaneously, ST increases. In an earlier study report of the same population than in the current study was observed a significant decrease in total amount of MVPA during the two-year follow-up among boys: 2.2 min ($p<0.001$) per day annually from 60 min/day at baseline. (Kallio et al., 2020). In addition, total ST increased significantly in both boys (20.7 percentage points/year) and girls (16.1 percentage points/year, $p<0.001$) (Kallio et al., 2020).

In study II, MVPA was found to have a cross-sectional association with the NSP experienced at least once a week among the boys. Boys who had MVPA at least 30 min during the day experienced weekly NSP less likely than boys who were less physically active. Studies on only NSP are rare, which gives only a little reference to compare the obtained results. In an earlier study, high PA was associated with more NP and occipital pain in adolescents (Auvinen et al., 2007). However, boys seem to benefit from PA also in an 11 year-long Danish National Birth Cohort study, where pre-adolescents' (N=45,555) spinal pain, in general, were followed, and PA was found to be associated with a lower risk of spinal pain among boys who also had a lot of screen time (Joergensen et al., 2021). However, with the cross-sectional design of this study, we cannot directly conclude whether the reduction in NSP was due to a higher amount of MVPA or whether NSP caused the reduced MVPA. Anyhow, the recommended amount of MVPA should be a part of school-aged children's lives, and the research results reminds us of that.

ST was not associated with NSP in the population of this dissertation, although it has been found to be associated with NP in adolescents previously. For example, Auvinen et al. (2007) reported that prolonged sitting is associated to adolescent neck and occipital pain. Similarly, Siekkinen et al. (2016) found that accelerometer-measured ST (average of 8 min) was associated with a 13% higher weekly prevalence of NP in children who were less than 60 min physically active per day. In support of the results for moderate-to-severe spinal pains in a cross-sectional study, in which the 2- and 5-h limits of ST were studied in 11- to 13 -year-olds, no association was found (Montgomery et al., 2022). It has been suggested that accelerometers are prone to mistakes when measuring ST by interpreting ST as non-wear time (Toftager, 2013). In this study, however, a limit value of 30 minutes was used when interpreting the non-wear time. Only a limit value as short as 10 minutes has been found to be too short for older youth and overweight subjects (Toftager, 2013). Conversely, sitting has been reported to be negatively related to children's preference for PA (Sheldrick et al., 2022). Therefore, efforts should be made to adhere to the MVPA recommendation for children and take care of the movement and activity in the environments of school-aged children.

No longitudinal associations were observed with accelerometer-measured PA or ST and NSP incidence in school-aged children of the study population (III). Similarly, Aartun et al. (2016) found either cross-sectional or longitudinal associations between accelerometer-measured PA and back pain in 11- to 15-year-olds. Because of the overlap in pain perceptions, they combined the pain categories of the spine into one. Therefore, the association between PA and NSP was not available for comparison. According to longitudinal study of Franz et al. (2017), interestingly, the change in the intensity of PA may play a role in neck, middle back, or lower back pain in 6- to 12-year -olds. When there was a shift from sedentary to moderate intensity PA, it appeared to protect against spinal pain; however, a shift from sedentary to vigorous PA increased the spinal pain incidences (Franz et al., 2017). However, this result inevitably brings the idea of the interaction of children's pain and MVPA, in general; children change their activity level guided by different sensations. If a child experiences a lot of pain, it can lead to a more sedentary lifestyle than without pain experiences. This must be considered, because particularly SB easily becomes a permanent lifestyle (Telama, 2009).

The self-reported physically passive screen time was associated with NSP incidence (III). From the categories of passive gaming time, TV viewing time, and social media time, passive gaming time and especially social media time were associated with NSP incidence during the first follow-up year; the more screen time, the more the probability of the NSP incidence increased. The association was not observed during the second follow-up year. The result confirms a recent Finnish national report (N=3408), which found that problematic social media users aged 11, 13, and 15 (9.4%) years suffer twice as much from NSP and headaches as non-problematic users (Paakkari et al., 2021). Although indications of this associations exist in previous studies regarding screen time and NSP in youth (Auvinen et al., 2017; Ben Ayed et al., 2019), to reveal a versatile understanding, the contribution of the use of different devices to pain should also be carefully investigated. It is possible that, for example, bending the spine over mobile phones or other portable devices can increase the mechanical stress on the cervical spine, which, in turn, can lead to cervical degeneration or some other developmental, medical, psychological, and social complications (Fares et al., 2017). Reports covering the COVID-19 pandemic period have shown a decreased preference in PA compared with time before (Sheldrick et al., 2022; Tapia-Serrano et al., 2022; Xiang et al., 2020) and a further increase in ST (Xiang et al., 2020), together with an increase in the number of various electronic devices in the home (Sheldrick et al., 2022; Tapia-Serrano et al., 2022). Research focused on NSP in school-aged children should be continued, also with up-to-date justification.

6.3 Role of physical fitness

Good physical fitness in any measured characteristic did not predict a lower NSP incidence in school-aged children in the study (IV). On the contrary, successful lower back extension increased the likelihood of NSP by 2.8-fold, and good performance in curl-up increased NSP by 1.8-fold. Only those children who had a good performance in the throwing–catching combination test had a 45% lower NSP incidence risk, although the association disappeared after adjustments of the analyzed model. Interestingly, an earlier school-based cohort study detected the significance of commonly used clinical tests to detect present or future NP, mid back pain, or lower back pain but reported that those specific tests did not have any predictive value; however, the specificity of those tests was observed to be high (Aartun et al., 2016).

Although the health benefits of good physical fitness for growing children are clear, good physical fitness characteristics were not associated with lower NSP incidence. No associations were observed in 1-year follow-ups either. Therefore, the evidence does not support the use of field-based fitness measurements for screening for NSP or future NSP. As the NSP prevalence and incidence are rather high in the studied age-group, the onset of etiology and treatment of NSP should be determined individually, for example, at the appointment of the physiotherapist who has an expertise with musculoskeletal disorders in young people.

When studying associations to children's NSP incidence in different studies, the associations of physical fitness can be difficult to detect for the same reasons as the associations of PA. Children live in a constantly changing situation, not only in terms of general growth and development but also in terms of pain experiences. Ståhl et al. (2008) reported the NSP to be fluctuating in nature among children. In terms of behavior, for example, Aartun et al. (2016) discussed that when children experience pain, they may change their PA. This may affect physical fitness and performance, which is logical because children have not yet formed permanent patterns or lifestyles, unlike adults. Therefore, the NSP incidence as the main variable in this study and the investigated variables that may be related to it may interact, vary, and be challenging to detect in general. The inconsistent associations between some fitness characteristics and the NSP incidence in this study indicate that further research is necessary to identify factors underlying the NSP incidence in school-aged children while developing new preventive tools that are contemporary and sensitive to the onset of NSP symptoms. In the current situation where NSP is common among youth, it would be necessary to develop NSP-sensitive assessment tools also for health-related fitness assessment, to support the health of the school-aged children in learning environments.

7 CONCLUSIONS

"It [pain] keeps me from doing a lot of things I like."
(Meldrum et al., 2009)

7.1 Practical implications

The educators of the children have an important role of being aware of the impact of health-related outcomes on children's ability to be successful in their lives. Equally, healthcare personnel must have access to up-to-date information. The web-based questionnaire used is well repeatable for collecting information on the prevalence of NSP during a school day from a large number of children. This is an important information as first, the data collection methods concerning NSP studies should be studied and be more unified in terms of school-aged children NSP, if comparable information about children's pain situations is aimed to be collected. The accurate identification of children's pain symptoms is the first step in the prevention and minimization of NSP among school-aged children, and currently, when prevalence and incidence of NSP are high, prevention should be implemented. In our efforts to determine the trajectory of development of NSP in school-aged children, we might be able to develop even more reliable and up-to-date tools based on the existing knowledge.

It might be beneficial to maintain and even increase the MVPA, at least among boys, as greater MVPA was found to be associated with fewer weekly NSP symptoms. This result is a useful addition to the list of benefits of PA and are valuable to all educators of children and adolescents. From parenting activities to the planning of services for children or families at the municipal level, increasing the contents of MVPA in activities is advisable. In addition, adults should be aware that screen time, particularly in terms of social media use and physically passive gaming, is a risk factor in the incidence of NSP in younger school-aged children. Since school-aged children nowadays spend time in front of screens for schoolwork, convey information is necessary regarding the risks of physically passive screen time and the incidence of NSP to different parties. Similarly, it is good for parents to be aware of these risks, so that they can guide their children to use the screens in a way that supports the health of the musculoskeletal system. As field-based general measurements of fitness characteristics in their current form cannot determine the risk of NSP incidence, concentrating on finding such NSP-specific measurements or other health measures in the future might be a good idea. Ideally, they could be easily connected to field-based measurements in schools.

The increased SB in the current era should be carefully studied and planned for both educational and non-educational use, and parents should be aware of the risks of screen time. Further research is necessary to study the NSP-promoting mechanisms behind the screen time and devices. The possibilities of PA as a factor in children's use of time and musculoskeletal health should be further explored through various interventions and longitudinal study settings. Young people themselves should have a crucial role to play in terms of research content as well as better future policies concerning PA and sedentariness.

7.2 Final conclusions

Information about the associations between PA or ST, physically passive screen time, and physical fitness characteristics with NSP was obtained in the original articles included in this dissertation. The studies showed that NSP can be reliably detected with a web-based pain questionnaire in school settings, MVPA is especially related to NSP experienced by boys, and screen time is associated with the NSP incidence in school-aged children; however, PA levels or physical fitness characteristics are not associated with NSP incidence (I, II, III, IV).

These findings indicate the importance of being aware of the children's PA levels and screen time use in growth environments. Both girls and boys increase their ST and screen time between the ages of 10 and 15 years. At the same time, the share of brisk PA decreases. It is necessary, for example, as an expert, to be able to assess which factors can be influenced to support a school-aged child suffering from NSP. In future studies, considering the achieved information related to children's research and the perspective of the variability of NSP is necessary to obtain mutually comparable information about NSP in school-aged children and find evidence-based basis for practical actions. Furthermore, as NSP seems to be a multifactorial challenge in school age, the incidence cannot be evaluated only in relation to individual variables but also preferably in relation to the widest possible health reference framework.

YHTEENVETO (SUMMARY IN FINNISH)

Kouluikäisten lasten niska-hartiakipujen suuri määrä herättää huolta ja asettaa ennaltaehkäisevälle työlle uusia haasteita. Niska-hartiakipujen esiintyvyyden ja ilmaantuvuuden ollessa nykyisellä tasolla, lasten ja nuorten kipujen taustaa tulisi selvittää tarkasti, sillä aiemmin koetuilla kivuilla voi olla merkitystä myös myöhemmin aikuisuudessa. Tämän väitöskirjan päämääränä on ollut selvittää, minkälainen yhteys fyysisellä aktiivisuudella, paikallaanoloajalla, ruutuajalla tai fyysisisillä kunto-ominaisuuksilla on kouluikäisten lasten kokemiin viikoittaisiin niska-hartiakipuihin kahden vuoden seurannassa.

Niska-hartiakipujen on todettu olevan sitkeitä ja jatkuvan usein aikuisuuteen asti. Fyysisellä aktiivisuudella puolestaan on todettu olevan paljon hyödyllisiä terveysvaikutuksia, joskin melko vähälukuiset tutkimukset ovat ristiriitaisia tuloksiltaan koskien fyysisen aktiivisuuden ja niska-hartiakipujen yhteyttä kouluikäisillä lapsilla. Samoin voidaan todeta paikallaanoloaikaan liittyvistä tutkimuksista. Liikkumattoman elämäntyylin on todettu olevan laadultaan pysyvää, jonka vuoksi jo kouluikäisten lasten keskuudessa on aiheellista tutkia siihen liittyviä tekijöitä. Fyysisesti passiivinen ruutuaika on mukana tarkasteltavissa muuttujissa edustaen liikkumatonta elämäntyyliä tässä väitöskirjassa. Fyysisten kunto-ominaisuuksien yhteyttä koululaisten niska-hartiakipuihin on perusteltua tutkia, sillä kouluissa suoritettavien kenttätestien terveyskriteereitä ja käytettävyyttä on painotettu koululaisten terveysperustaisessa mittaamisessa. Väitöskirjan aineistona on hyödynnetty Likesin Oppilaiden liikunta ja hyvinvointi -seurantatutkimuksen aineistoa vuosilta 2013–2015 ja väitöskirja koostuu yhteensä neljästä osajulkaisusta.

Aluksi, tutkimuksessa käytetyn verkkopohjaisen kipukyselyn toistettavuus testattiin 206 koululaisella (I). Kysely osoittautui luotettavaksi menetelmäksi toistettavuudeltaan. Kipukyselyä käytettiin arvioitaessa niska-hartiakipujen esiintyvyys (II) ja ilmaantuvuus (III, IV) tutkimuksissa. Seuraavaksi selvitettiin, onko kiihtyvyysanturein mitatulla fyysisellä aktiivisuudella tai paikallaanoloajalla yhteyttä 10–15-vuotiaiden (N=971) kouluikäisten lasten (12,6 ± 1,3 vuotta, 52,4 % tyttöjä) kokemiin viikoittaisiin niska-hartiakipuihin (II) tai niiden ilmaantuvuuteen (III). Tulokset (II) osoittivat, että pojilla, jotka kerryttivät 30 minuuttia tai enemmän reipasta tai rasittavaa fyysistä aktiivisuutta, oli 36 % pienempi todennäköisyys kokea niska-hartiakipuja kuin tätä vähemmän liikkuvilla. Sen sijaan fyysisellä aktiivisuudella tai paikallaanoloajalla ei havaittu yhteyksiä niska-hartiakipujen ilmaantuvuuteen seurannan aikana pojilla eikä tytöillä (II, III).

Pitkittäisasetelmassa analysoitiin paitsi fyysisen aktiivisuuden ja paikallaanoloajan, myös koululaisten itseraportoidun ruutuajan yhteyttä niska-hartiakipujen ilmaantuvuuteen. Analyysi ruutuajan yhteyksistä niska-hartiakipujen ilmaantuvuuteen tehtiin sekä kokonaisruutuajan, että erikseen TV-katselun, fyysisesti passiivisen peliajan ja sosiaalisen median käyttöajan suhteen. Ensimmäisen seurantavuoden aikana ruutuajan ja iän vuorovaikutus niska-hartiakipujen ilmaantuvuuteen oli merkitsevä, mutta ei toisen seurantavuoden aikana. Toisen vuoden aikana ei havaittu ruutuajoissa yhteyksiä niska-hartiakipujen ilmaantuvuuden välillä, mutta ensimmäisenä seurantavuonna kokonaisruutuajan (p = 0,020), fyysisesti passiivisen peliajan (p = 0,036) sekä sosiaalisen median käyttöajan (p = 0,023) ja viikoittaisten niska-hartiakipujen ilmaantuvuuden välillä löytyi tilastollisesti merkitsevä yhteys.

Lopuksi kouluikäisten lasten fyysisten kunto-ominaisuuksien yhteyksiä niska-hartiakipujen ilmaantuvuuteen tarkasteltiin kahden vuoden seurannassa (IV). Lähtötilanteessa ja yhden vuoden mittauspisteessä koululaiset osallistuivat Move! mittauksiin, joihin kuuluvat kyykistys, alaselänojennus täysistunnassa ja olkapäiden liikkuvuusmittaus (liikkuvuus), ylävartalonkohotus ja etunojapunnerrus (lihaskunto), sekä vauhditon 5-loikka ja heitto-kiinniotto-yhdistelmätehtävä (motoriset perustaidot) sekä 20 metrin viivajuoksu (kestävyyskunto). Lapset jaettiin tulosten perusteella tertiileihin heikko, keskiverto ja hyvä. Liikkuvuusmittauksissa ei käytetty tertiilijakoa, sillä jako oli dikotominen jo lähtökohtaisesti; tehtävä joko onnistui tai epäonnistui. Onnistunut tulos alaselän ojennuksessa oli yhteydessä niska-hartiakipujen suurempaan ilmaantuvuuteen (ristitulosuhde = 3,30) kahden vuoden seurannassa. Vatsarutistustehtävässä hyvät pisteet olivat yhteydessä suurempaan niska-hartiakipujen ilmaantuvuuteen ja heitto-kiinniottotehtävässä saadut hyvät pisteet olivat yhteydessä vähäisempään niska-hartiakipujen ilmaantuvuuden riskiin, kun verrattiin heikoiten suoriutuviin. Nämä tulokset näyttäytyvät kuitenkin epäjohdonmukaisina riippuen tarkasteltavasta ajanjaksosta tai käytetystä mallista (vakioitu/vakioimaton).

Väitöskirjan tulokset antavat tietoa fyysisen aktiivisuuden, paikallaanolon, ruutuajan ja fyysisten kunto-ominaisuuksien yhteyksistä koululaisten niska-hartiakipuihin. Tulokset osoittavat, että niska-hartiakipuja voidaan luotettavasti tutkia web-pohjaisella kyselylomakkeella kouluympäristöissä (I), ja että reipas tai rasittava fyysinen aktiivisuus on yhteydessä erityisesti poikien kokemiin niska-hartiakipuihin niitä vähentävästi (II). Fyysinen aktiivisuus, paikallaanoloaika tai fyysiset kunto-ominaisuudet eivät ole väitöskirjatutkimuksen perusteella yhteydessä niska-hartiakipujen ilmaantuvuuteen kouluikäisillä lapsilla (III, IV), mutta itseraportoitu fyysisesti passiivinen ruutuaika on (III).

Tulokset osoittavat, että aikuisten tulisi olla tietoisia lasten fyysisen aktiivisuuden tasosta ja ruutuaikamääristä kasvuympäristöissä. Sekä tytöt että pojat lisäsivät paikallaanoloaikaansa ja ruutuaikaansa 10–15-ikävuoden välillä. Samaan aikaan reippaan tai rasittavan fyysisen aktiivisuuden osuus laski. On tärkeää voida arvioida, mihin tekijöihin vaikuttamalla voimme tukea kipuilevan kouluikäisen hyvinvointia ja terveyttä. Tulevissa tutkimuksissa tulisi ottaa huomioon tähän mennessä saavutettu lapsia koskeva tutkimustieto sekä kipuihin ja kasvuikään liittyvä muuttujavaihtelu, jotta saadaan vertailukelpoista näyttöä kouluikäisten niska-hartiakipujen ennaltaehkäisevään toimintaan sekä kuntoutukseen.

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APPENDICES

Appendix 1. Pain questionnaire (English).

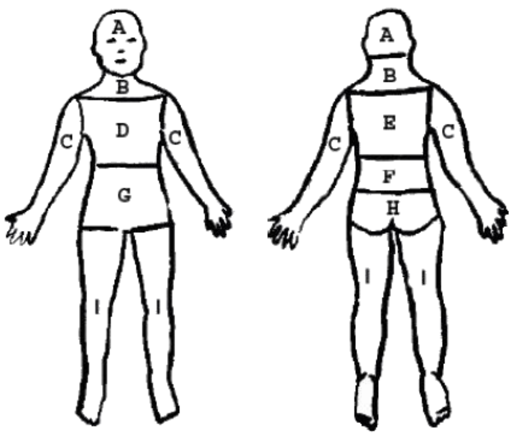
	Almost daily	More than once a week	About once a week	About once a month	Seldom or never
Headache (A)	O	O	O	O	O
Neck or shoulder pain / ache (B)	O	O	O	O	O
Upper extremity pain / ache (C)	O	O	O	O	O
Chest pain / ache (D)	O	O	O	O	O
Upper back pain / ache (E)	O	O	O	O	O
Lower back pain / ache (F)	O	O	O	O	O
Stomach ache (G)	O	O	O	O	O
Buttocks pain / ache (H)	O	O	O	O	O
Lower extremity pain / ache (I)	O	O	O	O	O
Difficulty falling asleep	O	O	O	O	O
Waking up at night	O	O	O	O	O

Have you injured any of the above-mentioned and pictured pain areas during the previous 3 months (for example, fallen, stumbled, breached during sport, etc.)

- O No
- O Yes

If you answered "Yes" to the previous question, please indicate the injured body areas. You can choose several options.

- O B
- O C
- O D
- O E
- O F
- O G
- O H
- O I



ORIGINAL PAPERS

I

TEST-RETEST REPEATABILITY OF QUESTIONNAIRE FOR PAIN SYMPTOMS FOR SCHOOL CHILDREN AGED 10–15 YEARS

by

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Test-retest repeatability of questionnaire for pain symptoms for school children aged 10 to 15 years

ABSTRACT

BACKGROUND AND AIMS: There is a growing body of evidence, that pain is common at school age. Less is known about the repeatability of pain questionnaires for children. This study aimed to assess the test-retest repeatability of the Finnish version of the electronic pain questionnaire for school-aged children.

METHODS: Primary (n=79) and lower secondary (n=127) schoolchildren aged 10 to 15 years from two schools from the Jyväskylä region of Finland, filled in an electronic questionnaire twice in an interval of two weeks. It captured the frequency of pain symptoms with a 5-point Likert-scale questionnaire covering nine areas of the body for the last three months. The intraclass correlation coefficient (ICC) values 0.40–0.59 reflected fair and 0.60–0.74 good repeatability.

RESULTS: The highest prevalences of pain were in the head (29%) and neck and shoulder (NS) (23%) areas. ICC values showed good repeatability for questions about pain frequency in the head, NS and lower extremities. In primary school, these values were good in the lower extremities and fair in NS, lower back and the head. In lower secondary school, the ICC values were good in NS and the head, fair in the stomach and lower extremities.

CONCLUSIONS: This electronic questionnaire was an acceptably repeatable indicator to measure the frequency of pain in the most prevalent pain areas: the head and NS.

IMPLICATIONS: It is important to be aware of the impact of health-related outcomes on children's ability to be successful in their lives. With the help of a simple electronic questionnaire, it is possible to cost-effectively capture, for example, the prevalence and frequency of pain during the school hours. The identification of children's pain symptoms accurately provides more possibilities to prevent and to minimize the chronic pain among schoolchildren.

Keywords: Pain, children, repeatability, questionnaire

BACKGROUND AND AIMS

About 15% to 25% of all children and adolescents report recurrent or chronic pain conditions (1). The limbs (34%), head (26%), abdomen (16%) and back (15%) have reported to be the most common pain areas among 12–18-year old adolescents (2). Already 6–8-year old children has been reported to have frequent pain most commonly in the lower limbs (40%) and head (31%) whereas back and neck-shoulder area pain prevalences were 7% (3). Studies have shown that children with long-term pain report similar or more disabilities in daily life than children with chronic somatic disorders (2). Disabilities manifest in social functioning, school participation, sports activities, and/or sleeping problems (4). Pain in children and adolescents is also a burden on their families and to society (2). Pain in adulthood is known to have severe economic consequences (5), but even in adolescence, long-term pain may have extensive financial consequences (6).

Reliable and valid pain assessment tools are needed for research and clinical purposes to accurately measure the frequency of pain in children. However, information about the repeatability of these questionnaires is limited. To study the prevalence and frequency of pain symptoms, self-report questionnaires are common instruments. Hakala et al. 2002 studied the changes in musculoskeletal pain in 189 894 school children in the Adolescent Health and Lifestyle survey in 1985–2001. They captured the prevalence of pain during the past half a year and the questions were categorized on four levels (seldom, once a month, one a week and daily). The test-retest reliability coefficient for back and neck pain were 0.48–0.67 and lower back pain ~0.60 (7), when the questionnaire was retaken after four to six weeks. Jannini et al. 2011 studied the frequency of musculoskeletal pain during the previous three months in the neck, upper limbs, chest, trapezoid muscles, lower back and lower limbs in children using a questionnaire earlier developed for adolescents (8). The test-retest reliability of the questionnaire with a 10 day`s interval was substantial with a Kappa [κ] value of 0.72. The whole questionnaire contained 70 questions, and conclusions about the repeatability of pain questions only are not available.

El-Metwally et al. 2007 captured the information on musculoskeletal pain frequency (neck, upper limbs, chest, upper back, lower back, buttocks) in Finnish schoolchildren with a structured 5-point Likert-scale questionnaire (9). The test-retest reliability of the questionnaire in detecting children with pain at least once per week was good with a Kappa [κ] value of 0.90. Although this questionnaire has been widely used in research (9, 10, 11), its repeatability has not been studied in Finnish children. The purpose of this study was to assess the test-retest repeatability of the pain-related questions using the Finnish electronic version of this questionnaire, which categorizes pain frequency into 5-levels among school-aged children.

METHODS

Participants

Two schools from the Jyväskylä region of Finland, were included in this study. The total study population included 206 children from grades 4 to 9 (aged 10–15 years, mean age 13.8, SD 1.8 years (56% girls)). Of these, 79 were 10-13-year-old children from a primary school (mean age 11.9, SD 0.9) years and 127 were 13–15-year-old children from a lower secondary school (mean age 15.1, SD 0.9 years). Written informed consent was obtained from all the children and their guardians before participation in the study, according to the Declaration of Helsinki. Pain symptom questionnaires were filled out twice – in spring 2015 in the lower secondary school and in autumn 2015 in the primary school – as part of the research related to the Finnish Schools on the Move program. Its study protocol was approved by the Ethics Committee of the University of Jyväskylä.

Instrument and procedure

The pain questionnaire used in this study has previously been structured for study purposes in Finland (10, 11). The 5-level frequency classification was originally adopted from a nationwide survey on health and health-related behavior in schoolchildren by the WHO (12). The questionnaire captures the frequency of pain symptoms in various areas of the body (head, NS, upper limb, chest, stomach, upper back, lower back and buttocks, lower limb regions) during the last three months. The questionnaire contains a figure of the human body with zones and written names of the corresponding body areas to ensure that the regions of the body were understood correctly. It was possible for all participants to seek help on the questionnaire from an adult in the classroom. The original pain questionnaire in Finnish as well as in English translation can be seen in Appendix 1 and 2.

The electronic questionnaire was filled in during school hours with an interval of two weeks. The pupils answered to the question: “How often have you had symptoms in the last three months?” and listed body areas accordingly, such as “neck or shoulder pain or ache.” There were five answer options given to classify the pain symptoms: 1) almost daily, 2) more than once a week, 3) about once a week, 4) once a month, and 5) seldom or never. The pupils were also asked to report if the pain originated due to a trauma: “Have you injured any of the above-mentioned and pictured pain areas during the previous three months (for example, fallen, stumbled, breached during sport, etc.)?” Options were “yes” or “no.” If the answer was “yes,” they were asked to choose and mark the injured body area on the menu with the help of the body map. Pains due to traumatic causes were excluded from the analysis. In further analysis, the 5-level answers were grouped into a dichotomous scale of symptoms occurring at least once a week and less than once a week.

Data Analysis

Descriptive statistics are expressed as means with standard deviations (SD) or 95% confidence intervals (CI) and counts with percentages. Test-retest reliability was tested with the intraclass correlation (3,1), Two-Way Mixed Single Measures, for the 5-point scale and with Cohen`s Kappa [κ] coefficient and global percent agreement for a 2-point scale. ICC values < 0.40 reflect poor, 0.40–0.59 fair, 0.60–0.74 good and 0.75–1.00 excellent repeatability (13). Kappa [κ] values of 0.00 to 0.20 represents poor, 0.21 to 0.40 fair, 0.41 to 0.60 moderate, 0.61 to 0.80 good, and 0.8 to 1.00 very good repeatability (14). Agreement among respondents between the first and second tests is presented as a percent, showing the percentage of answers which stayed in the exactly same category during both measurements.

RESULTS

Of the 206 children from grades 4 to 9 who were invited into the study, 83% (N= 181) filled in questionnaires twice and were included in the analysis. Seventy-seven children (41 boys and 36 girls) were from primary school (grades 4 to 6) and 104 children (40 boys and 64 girls) from lower secondary school (grades 7 to 9). The highest prevalence of pain symptoms observed were in the head (29%) and NS area (23%) (Table 1). In both the head and NS, the prevalence of pain was more than twice as high in lower secondary school students (37% and 30%) than in primary school students (16% and 13%).

The repeatability of the pain questionnaire is presented in Table 2. In the analysis with a 5-point scale, questions about pain in NS, the head and lower extremities had good repeatability in all schoolchildren (ICC 0.67, 0.66 and 0.62, respectively). In primary schoolchildren, the ICC for the lower extremities (ICC 0.70) was good, and for NS (0.59), lower back (0.58) and the head (0.56) the ICC was fair. Other questions had poor repeatability (ICC < 0.40). In the analysis of lower secondary schoolchildren, the ICC for pain in NS and the head were good (0.70, 0.69), and the stomach (0.59) and lower extremities (0.57) were fair, while the other areas remained poor.

In secondary analysis using a 2-point scale and Kappa [κ] coefficient, the questions about pain in the head (0.70) and NS (0.68) had good repeatability in all schoolchildren. The agreement percentage varied between 88–94%. In primary schoolchildren, four pain area questions reached good repeatability with the following Kappa values: lower extremities (0.79), NS (0.67), lower back (0.67) and head (0.66). The other pain areas had moderate repeatability, except the upper extremities had fair repeatability (0.30). In lower secondary schoolchildren, questions about the head (0.69) and NS (0.67) were good, while the lower extremities (0.52), stomach (0.47) and upper extremities (0.45) were moderately repeatable. The agreement percentage in primary and secondary school varied between 92–98% and 83–92% respectively.

DISCUSSION

This study evaluated the test-retest repeatability of pain-related questions in a questionnaire for Finnish school children aged 10 to 15 years. Almost one third of the children reported head pain and a quarter reported pain in the NS area during the last three months. The most repeatable pain area questions were those related to the head, NS and lower extremities in all schoolchildren using an instrument with either a 5-point or 2-point scale.

In general, there was a tendency for higher frequencies of pain in lower secondary schoolchildren than in primary schoolchildren. Particularly, the frequencies of head and NS pain were almost three times higher in lower secondary schoolchildren than in primary schoolchildren. A previous cohort study in Finnish children showed similar results, where the prevalence of at least weekly experienced neck-shoulder pain and lower back pain was much more common in older age groups (14-, 16- and 18-year-old children) than in 12-year-old children (7). Kappa is also dependent on the prevalence of the condition (15). This can partly explain higher Kappa values in most frequent pain localizations. Thus, we should be careful when comparing Kappa values from different studies when the prevalence varies.

When studying frequencies in children and adolescents and the questionnaire as an instrument, the recall time can be an important factor. In a Finnish study, the test-retest reliability was measured with a four-to-six-week interval with a six-month recall time over three different years (7). The results for back and neck pain repeatability ([κ] 0.48–0.67) were similar compared to our study results. In a Brazilian study, to reduce the effects of memory bias, respondents, 10- to 19-year-old children were asked to report on musculoskeletal symptoms suffered during the previous three months (8). The test-retest reliability of the questionnaire with a 10-day interval was substantial with a Kappa [κ] value of 0.72. In an American study of seventh- and eighth-graders, for evaluation of the internal consistency of a pilot survey with questions about back and neck pain, the test-retest with a one-week interval, for evaluation of the internal consistency of a pilot survey questions for back and neck pain showed [κ] 0.54 as a mean (16). In this study, the recall time was "present school year." However, the age of the population and differences in the test-retest settings of these studies affect comparability to our study.

In addition to recall time, respondent characteristics and question characteristics may affect the reliability of responses in surveys (17). When responding to the present pain questionnaire, children were asked to rate the frequency of their perceived pain on a 5-point Likert-type scale. In different studies, the number of answer choices tends to vary, ranging from two response options up to seven. In this study, the main result remained similar on both ICC and Kappa analyses. In our secondary analysis, slightly better values for younger children in 2-point scale Kappa analysis suggests that it would be easier for younger children to answer with fewer options. Reading comprehension becomes easier with age. Borgers et al. 2000 noticed that older children are better at reading and comprehension and thus produce better data quality (18). Bae et al. 2010 reported, that the older children are, the more repetitive the answers are (19). Our secondary analysis finding should be confirmed in a further study by collecting data with both a 5-level and 2-level classification and comparing these directly.

Limitations

The weakness of this study is its relatively small sample. The strength of the study was a high response rate in both age groups, partly because the data was collected during school days in classrooms. The electronic questionnaire ensured that there were no missing values. If the children failed to answer a question, the system did not allow them to proceed. Also, the time interval between two data collections was accurate. In school, children are also able to give more subjective answers, which are free from their parents' opinions.

Conclusions

This electronic questionnaire, filled in during school hours with an interval of two weeks, had an acceptable repeatability to screen the frequency of pain both in primary and lower secondary schoolchildren in most prevalent pain areas in both age groups: pain in the head and NS. The 5-point scale answering options were equally repeatable in younger and older children. These results are encouraging regarding the use of this measurement in further studies when measuring lower secondary schoolchildren.

IMPLICATIONS

It is important to be aware of the impact of health-related outcomes on children's ability to be successful in their lives. With the help of a simple electronic questionnaire, it is possible to cost-effectively capture, for example, the prevalence and frequency of pain during the school hours. The identification of children's pain symptoms accurately provides more possibilities to prevent and to minimize the chronic pain among schoolchildren.

Authors' statements

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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.

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Table 1. The prevalence of pain experienced once a week or more often at different body areas during first survey, for all children and separately for children in primary and lower secondary school.

Pain area	All (n=181)		Primary school (n=77)		Secondary school (n=104)	
	N	%	N	%	N	%
Head	60	29	13	16	47	37
Neck and shoulder	48	23	10	13	38	30
Upper extremities	17	8	4	5	13	10
Chest	12	6	3	4	9	7
Upper back	26	13	8	10	18	14
Lower back	27	13	9	11	18	14
Stomach	25	12	7	9	18	14
Buttocks	17	8	6	8	11	9
Lower extremities	26	13	7	9	19	15

Table 2. The test-retest reliability of the pain questions measured two weeks apart in all children, and separately for children in primary and lower secondary school. Trauma includes reported injury at first, second or both surveys.

Pain Area	N	Trauma N	ICC (5-point scale) Kappa (95% CI)	2-point scale Kappa (95% CI)	2-point scale Agreement (% same)
All					
Head	161	20	0.66 (0.56, 0.74)	0.70 (0.58, 0.83)	88
Neck and shoulder	168	13	0.67 (0.58, 0.75)	0.68 (0.55, 0.82)	89
Upper extremities	146	35	0.36 (0.21, 0.50)	0.41 (0.14, 0.68)	92
Chest	177	4	0.36 (0.23, 0.48)	0.35 (0.03, 0.66)	94
Upper back	170	11	0.40 (0.26, 0.52)	0.33 (0.10, 0.56)	89
Lower back	167	14	0.40 (0.26, 0.52)	0.36 (0.15, 0.58)	87
Stomach	174	7	0.49 (0.37, 0.59)	0.44 (0.23, 0.66)	90
Buttocks	173	8	0.38 (0.25, 0.50)	0.21 (-0.03, 0.46)	90
Lower extremities	109	72	0.62 (0.48, 0.72)	0.60 (0.33, 0.87)	94
Primary School					
Head	64	13	0.56 (0.36, 0.71)	0.66 (0.39, 0.93)	92
Neck and shoulder	71	6	0.59 (0.42, 0.72)	0.67 (0.40, 0.94)	93
Upper extremities	56	21	0.21 (-0.05, 0.45)	0.30 (-0.21, 0.80)	93
Chest	74	3	0.28 (0.06, 0.48)	0.49 (-0.13, 1.10)	97
Upper back	71	6	0.38 (0.16, 0.56)	0.47 (0.03, 0.91)	94
Lower back	73	4	0.58 (0.40, 0.71)	0.67 (0.40, 0.94)	93
Stomach	73	4	0.30 (0.08, 0.49)	0.36 (-0.04, 0.76)	92
Buttocks	73	4	0.44 (0.24, 0.61)	0.47 (0.03, 0.91)	95
Lower extremities	43	34	0.70 (0.51, 0.83)	0.79 (0.39, 1.19)	98
Secondary School					
Head	97	7	0.69 (0.57, 0.78)	0.69 (0.54, 0.84)	86
Neck and shoulder	97	7	0.70 (0.58, 0.79)	0.67 (0.51, 0.83)	87
Upper extremities	90	14	0.39 (0.20, 0.55)	0.45 (0.13, 0.77)	91
Chest	103	1	0.37 (0.19, 0.52)	0.29 (-0.07, 0.65)	92
Upper back	99	5	0.39 (0.21, 0.55)	0.26 (-0.01, 0.53)	85
Lower back	94	10	0.23 (0.03, 0.41)	0.11 (-0.14, 0.36)	83
Stomach	101	3	0.59 (0.44, 0.70)	0.47 (0.22, 0.73)	88
Buttocks	100	4	0.36 (0.18, 0.52)	0.07 (-0.17, 0.31)	87
Lower extremities	66	38	0.57 (0.38, 0.71)	0.52 (0.18, 0.86)	91

Appendix 1

OIREET

Kuinka usein sinulla on ollut seuraavia oireita edellisen 3 kuukauden aikana (vartalon osat A-I alla olevissa kuvissa)? Merkitse sopivan vaihtoehdon kohdalle.

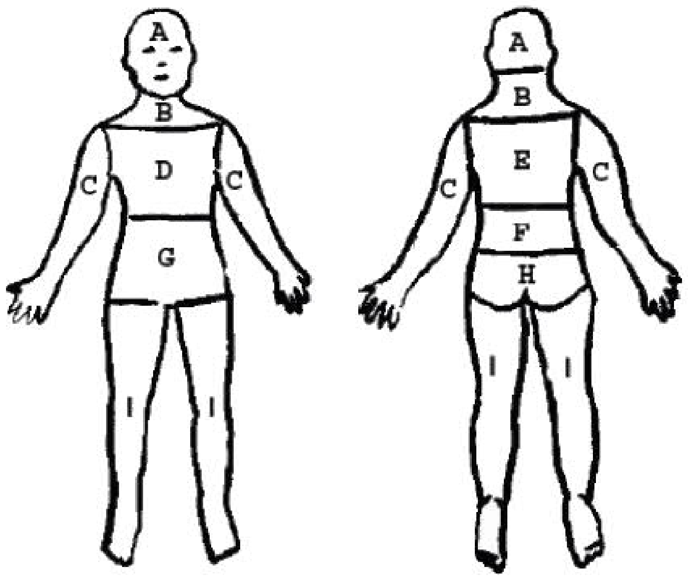
	Lähes päivittäin	Useammin kuin kerran viikossa	Noin kerran viikossa	Noin kerran kuukaudessa	Harvemmin tai ei koskaan
Päänsärkyä (A)	O	O	O	O	O
Niska-hartiakipua tai särkyä (B)	O	O	O	O	O
Yläraajojen kipua tai särkyä (C)	O	O	O	O	O
Rintakehän kipua tai särkyä (D)	O	O	O	O	O
Yläselän kipua tai särkyä (E)	O	O	O	O	O
Alaselän kipua tai särkyä (F)	O	O	O	O	O
Vatsakipuja (G)	O	O	O	O	O
Pakaroiden kipua tai särkyä (H)	O	O	O	O	O
Alaraajojen kipua tai särkyä (I)	O	O	O	O	O
Vaikeuksia päästä uneen	O	O	O	O	O
Heräilemistä öisin	O	O	O	O	O

Oletko loukannut edellisen 3 kuukauden aikana jonkin edellä mainituista ja kuvassa olevista kipualueista? (esimerkiksi kaatunut, kompastunut, loukannut urheilussa jne.)

- O En
- O Kyllä

Jos vastasit edelliseen kysymykseen kyllä, niin merkitse, mitkä alueet olet loukannut. Voit valita monta vaihtoehtoa.

- O A
- O B
- O C
- O D
- O E
- O F
- O G
- O H
- O I



Appendix 2

SYMPTOMS

How often have you had symptoms in the last three months? (body parts A-I in the picture below)? Mark the appropriate option.

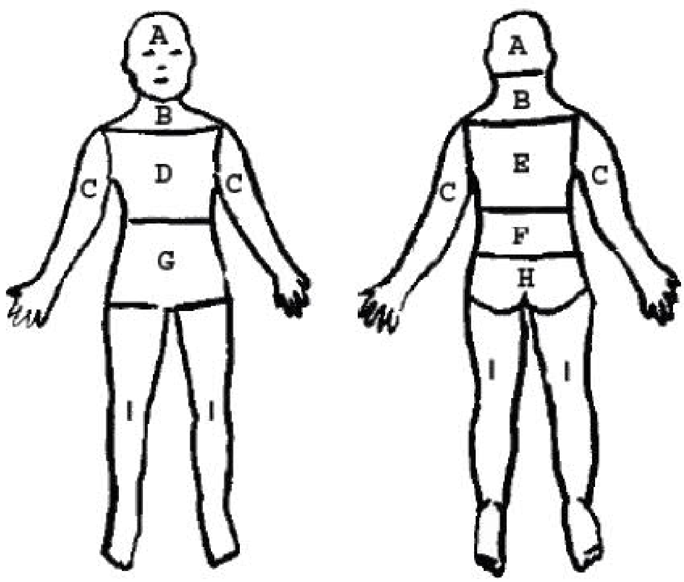
	Almost daily	More than once a week	About once a week	About once a month	Seldom or never
Headache (A)	○	○	○	○	○
Neck or shoulder pain / ache (B)	○	○	○	○	○
Upper extremities pain / ache (C)	○	○	○	○	○
Chest pain / ache (D)	○	○	○	○	○
Upper back pain / ache (E)	○	○	○	○	○
Lower back pain / ache (F)	○	○	○	○	○
Stomach ache (G)	○	○	○	○	○
Buttocks pain / ache (H)	○	○	○	○	○
Lower extremities pain / ache (I)	○	○	○	○	○
Difficulty falling asleep	○	○	○	○	○
Waking up at night	○	○	○	○	○

Have you injured any of the above-mentioned and pictured pain areas during the previous three months (for example, fallen, stumbled, breached during sport, etc.)

○ No
○ Yes

If you answered ”Yes” to the previous question, please indicate the injured body areas. You can choose several options.

○ B
○ C
○ D
○ E
○ F
○ G
○ H
○ I



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Lower back	27	13	9	11	18	14
Stomach	25	12	7	9	18	14
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Chest	74	3	0.28 (0.06, 0.48)	0.49 (-0.13, 1.10)	97
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II

ASSOCIATIONS OF NECK AND SHOULDER PAIN WITH OBJECTIVELY MEASURED PHYSICAL ACTIVITY AND SEDENTARY TIME AMONG SCHOOL-AGED CHILDREN

by

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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± 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

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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.

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

	All n=905	Girls n=475	Boys 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.

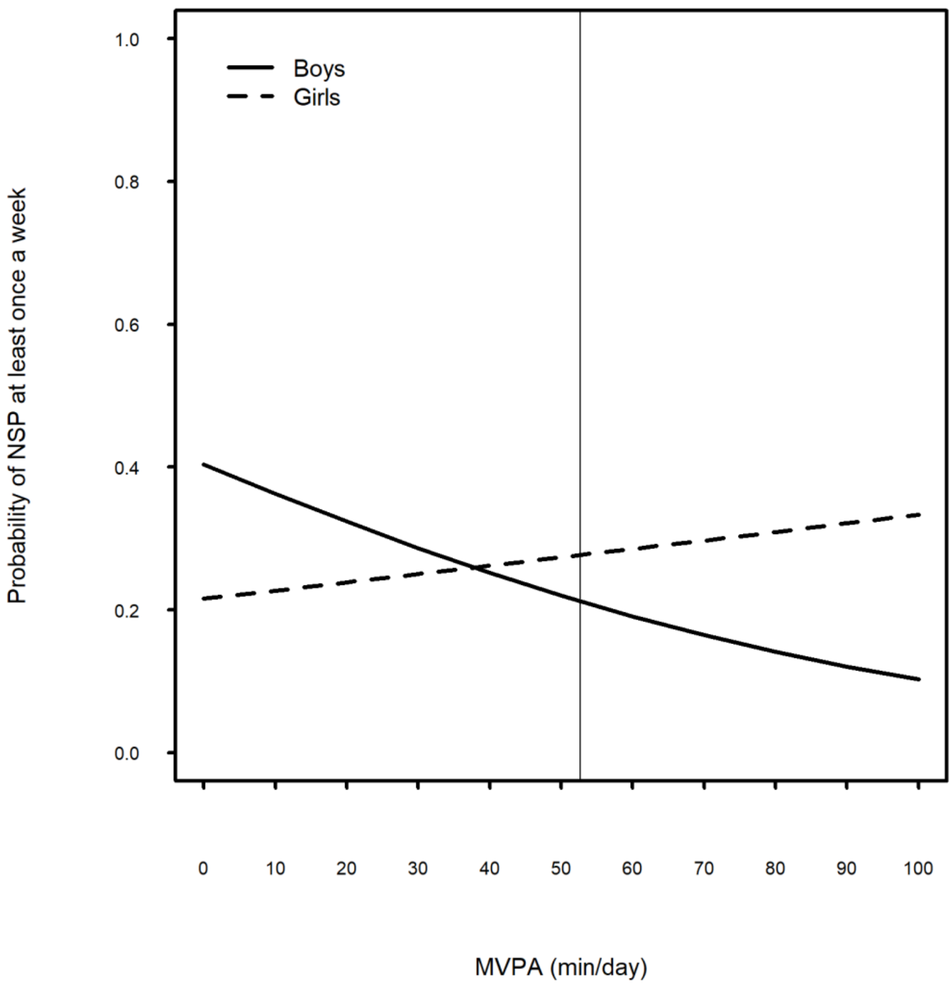
Table 3. Association between sedentary time (ST) and neck and shoulder pain. Results of multinomial logistic regression analyses.

	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.



III

PHYSICAL ACTIVITY, SCREEN TIME AND THE INCIDENCE OF NECK AND SHOULDER PAIN IN SCHOOL-AGED CHILDREN

by

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Physical activity, screen time and the incidence of neck and shoulder pain in school-aged children

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This study investigated the associations of accelerometer-measured physical activity, sedentary time and screen time with the incidence of neck and shoulder pain in school-aged children over a two-year follow-up. Children (aged 10–15) were measured at baseline 2013 (T0) (n = 970) and at follow-ups 2014 (T1) and 2015 (T2). Neck and shoulder pain frequency and screen time were determined with a web-based questionnaire. Daytime moderate to vigorous physical activity and sedentary time were measured with an accelerometer. Logistic regression was applied, and the results were adjusted for age, gender, body mass index and bedtime. Accelerometer-measured physical activity or sedentary time at baseline were not associated with the incidence of neck and shoulder pain at the two-year follow-up. Associations of neck and shoulder pain incidence with overall screen time ($p = 0.020$), and especially with passive gaming time ($p = 0.036$) and social media time ($p = 0.023$) were found at the first but not the second follow-up. The neck and shoulder pain incidence associated with overall screen time, passive gaming time and social media time at the first follow-up. The importance of limiting screen time, should be explored in order to find new approaches in preventing neck and shoulder pain in school-aged children.

Research on the predictors of neck and shoulder pain (NSP) in children is lacking despite the fact, that NSP has become one of the most persistent musculoskeletal pain symptoms among school-aged children[1,2]. The increase in NSP among youth was noticed in the Finnish study 1990s, at around the same time as the use of information and communication technology was becoming increasingly common[3]. A similar increase in NSP has also been reported in other western countries[4]. Neck pain is also a common global problem today. The years lived with disability in age standardized rates are the highest in Western Europe and East Asia (461/100 000) in general population according the latest Global burden of disease study 2017[5].

Identifying the factors influencing the development of NSP in young populations is an important first step in the early prevention of this major public health problem.

There is conflicting information about the long-term factors influencing the NSP. The factors that have been observed to predict the incidence of NSP in children include physical and / or psychological stress, personal hobbies, and the co-occurrence of other musculoskeletal symptoms[6]. NSP has also been found to be hereditary (68%)[6] and it has been reported that children from families with a history of musculoskeletal pain are 58% more likely than other children to suffer from pain symptoms[7]. High levels of PA have been reported to be associated with a higher prevalence of NSP in girls[8] but a lower prevalence in boys[9]. In a retrospective study, maintaining PA from childhood to adolescence inhibited NSP[10]. In general, the presence of pain has been associated with reduced PA in school-age[11]. Some studies have found no longitudinal association between spinal pain or NSP and the PA level[6,12,13]. For example, a 25-year follow-up study of originally 9- to 17-year-olds showed good flexibility in boys and endurance strength in girls to be associated with less tension neck symptoms in adulthood but no association between adolescent PA assessed by questionnaire and adulthood tension neck was found[13]. A four-year follow-up of 9- to 12-year-olds found no association between PA level measured by questionnaire and future persistent neck pain[6]. A later study in 11- to 15-year-olds in which PA was measured with an accelerometer also found no association of neck pain with PA in children at the two-year follow-up[12].

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The WHO has identified important areas for further research, one of which is the differences in the health effects of PA and its different types and domains, including ST and screen time[14]. Frequent computer use has been found to be associated with a higher prevalence of NSP in children[8,15]. However, computer-related activities or screen time have not been related to NSP in all studies[16,17]. According to a recent report, problematic use of social media was associated with NSP in children[18].

Given the mixed evidence for the impact of reduced PA on NSP, this study investigated the longitudinal associations between accelerometer-measured PA and the incidence of NSP in 10–15 -year-old children. The article presents the results of a two-year follow-up, complementing our previous cross-sectional analysis of the same population[9]. The specific aim was to ascertain whether accelerometer-measured PA or ST and self-reported screen time explain the incidence of NSP in school-aged children.

Material and methods

As a part of a research related to the national “Finnish Schools on the Move” program[9,19–22], 1710 school-aged children in grades 4–7 across Finland were invited to participate in the study. Of these children, 970 participated (mean 12.5 years ± 1.3 years; 52.5% girls) and 684 (75.6%) provided information on all the study variables at baseline. We utilized data from three measurement points: spring 2013 (T0, baseline), spring 2014 (T1) and spring 2015 (T2).

The incidence of NSP refers to new cases, where pain is reported as having occurred at least once a week during the past three months. Analyzes were conducted on the data obtained between baseline and the second measurement point (T0–T1) and on the data obtained between the second and third measurement points (T1–T2). In accordance with the Declaration of Helsinki, a written informed consent was obtained from all the children and their guardians before participation. The study setting was approved by the ethics committee of the University of Jyväskylä (January 2012).

The participants completed a web-based questionnaire five times during school hours in 2013–2015[21]. The pupils answered the question: “How often have you had the following symptoms in the last three months?” The accompanying list of symptoms included “neck or shoulder pain or ache”. Participants responded to each symptom by selecting one of five pain frequency options: (1) almost daily, (2) more than once a week, (3) about once a week, (4) once a month, and (5) rarely or never. The questionnaire included a figure of the human body divided into named zones to ensure that the body regions were understood correctly. It was possible for all participants to ask for help with the questionnaire from an adult in the classroom. For the incidence analysis, the answers on NSP symptoms during last three months were recoded into two categories: (1) once a week or more often and (2) less than once a week. Children were also asked to report if the pain originated due to a trauma: “Have you injured any of the above-mentioned and pictured pain areas during the previous three months (for example, fallen, stumbled, breached during sport, etc.)?”[21]. Children who reported trauma during last three months in the neck and shoulder area were excluded from the analysis. The test–retest repeatability of the NSP questionnaire has been reported to be substantial (Kappa [κ] 0.68 for the 2-point scale and intraclass correlation coefficient [ICC] 0.67 for the 5-point scale)[21].

Screen time was asked with five questions, separately for weekdays and weekend days[20]. Children were asked to state how many hours a day they usually spend (1) watching TV, videos (including YouTube and other sources) or DVD movies, (2) playing computer or console games (excluding sports games like Wii Fit, Xbox KINECT or PlayStation Moves), (3) doing homework on a computer or other electronic device (iPad, etc.), (4) communicating with others through social media such as email, SMS, Twitter, Facebook, chat and (5) reading printed or electronic books, magazines, newspapers, etc. outside of class (e.g. at home, during school breaks, at meal breaks etc.). All items were answered on a nine-point scale: (1) not at all, (2) about half an hour a day, (3) about an hour a day, (4) about 2 h a day, (5) about 3 h a day, (6) about 4 h a day, (7) about 5 h a day, (8) about 6 h a day, and (9) about 7 h a day or more. The response options were coded according to the number of hours: 0, 0.5, 1, 2, 3, 4, 5, 6, 7. The screen time items analyzed were TV viewing time, game-playing time and social media time. Test–retest agreement for self-reported screen time questions has been moderate to substantial (ICC 0.54–0.74)[23].

Daytime PA and ST were assessed 5 times with a hip-worn ActiGraph triaxial GT3X + and wGT3X + accelerometers (ActiGraph, Pensacola, Florida, USA) in 2013–2015[20]. Participants were instructed to wear the monitor on the right hip during waking hours for seven full consecutive days, except while bathing or doing water-based activities. The 30 Hz raw acceleration data were downloaded, standardly filtered and converted to 15-s epochs using Actilife software (version 6.11.7). A customized Visual Basic macro for Excel software was used for data reduction. Readings including ≥ 500 min/day on three days (two valid weekdays and one weekend day) or more of time measured between 7:00 and 23:00 were required for a valid monitoring period. Periods of 30 min of consecutive zero counts were defined as non-wear time. Counts over 20 000 per minute (cpm) were omitted as spurious accelerations[24]. The cut-points proposed by Evenson et al. (2008) were used to calculate MVPA (≥ 2296 cpm) and ST10min (≤ 100 cpm)[25]. Accelerometer-based ST (ST10min) was the absolute wear-time in which at least 10 min were sedentary (< 100 cpm). MVPA and ST10min were calculated as weighted means of the weekday and weekend day means (Total PA = [5 * mean weekday PA + 2 * mean weekend day PA]/7).

Each pupil’s weight and height were measured and used to calculate their body mass index (BMI). Weight was measured in light clothing using bioelectrical impedance analysis (InBody 720, Biospace Co., Ltd). Height was measured with a portable Charder HM 200P instrument. The measurement was performed twice. If the results between the measurements differed by more than 0.4 cm, a third measurement was performed. The mean of the two closest results was used in the analysis. Bedtime was asked with the question: “When do you usually go to bed if you have to go to school next morning”? The response options were selected from a list of times specified in half hour intervals (from 1 to 7): no later than 21:00, 21:30, 22:00, 22:30, 23:00, 23:30 or 24:00 or later.

Statistical analysis. The variables observed at the three measurement points, i.e., baseline (T0), one-year follow-up (T1) and two-year follow-up (T2) were analyzed. In the analyses MVPA and ST (ST10min) was used as absolute values min/day. Descriptive statistics are presented as mean values and standard deviations (SD) or percentages (%). NSP incidence was calculated as follows: for pupils with NSP less than once week at T0 and T1 the NSP incidence variable assigned the value 0 (reference category); if the participant's NSP was higher than the reference category value at T1, the NSP incidence variable was assigned the value 1. Children with NSP at least once a week at T0 were not included in the analysis. The unequal probabilities of selection (by age and gender) were controlled for the modeling by using sampling weights, which were constructed by using information on general population structure obtained from Official Statistics of Finland[26]. Model parameters were estimated by using full information maximum likelihood method (FIML)[27] with robust standard errors (MLR). Missing data were assumed to be missing at random (MAR). Because data were clustered in schools and ages, standard errors were calculated by using a special feature of Mplus (TYPE = COMPLEX). To study the incidence of NSP in the different independent variables adjusted by spinal area injuries (upper or lower back, n = 81), BMI, bedtime (23.00 or later), age and gender, logistic regression analysis with was conducted. Dropout was studied by using the FIML, where the model was corrected with a missing value. The analyzes were conducted using SPSS 25.0 for Windows (SPSS Inc., Chicago, IL) and Mplus 7.0 using a 5% significance level, i.e., p-values ≤ 0.05 indicating a significant association.

Results

No important differences were found between the participants with (n = 684) or without (n = 286) complete data in all relevant variables. At baseline, 947 children and at the last measurement point 798 children answered the survey. At baseline (T0), 26% of children reported experiencing NSP at least once a week. The prevalence of NSP in girls and boys was 28% and 23%, respectively, at T0 ($p = 0.091$) and 31% and 21% at T2 ($p = 0.001$). The incidence of NSP between T0–T1 was 15% and between T1–T2 18%. The incidence of NSP between T0–T1 was higher in girls than boys (girls 19% vs. boys 11%, $p = 0.006$) but no difference was observed between T1–T2 (girls 20% vs. boys 16%, $p = 0.207$) (Table 1). At T2, mean MVPA among all children was 7.5 min less and mean sedentary time was approximately 1 h greater than at baseline (T0) (Table 1).

Self-reported screen time was analyzed as whole and separately for TV-viewing, passive gaming and social media time. During the follow-up, boys accumulated 0.9 h/day of screen time, while girls accumulated 1 h/day of social media time. Mean screen time differed significantly by gender during the follow-up (T0: girls 4.0 h/day vs. boys 4.5 h/day, $p = 0.002$, T2: girls 4.6 h/day vs. boys 5.4 h /day, $p < 0.001$) (Table 1). In the whole sample, MVPA correlated with NSP at baseline and sedentary time correlated with NSP at baseline and T1. A weak correlation between sedentary time and the incidence of NSP between T0–T1 was detected. Screen time correlated with NSP in all children but not with the incidence of NSP. Social media time correlated with NSP at each measurement point (Table 2).

At baseline, 767 children participated in PA monitoring with accelerometers, of whom 319 participated in the second follow-up (T2). Accelerometer-measured MVPA or ST were not associated with the incidence of NSP between T0–T1 or between T1–T2 (Table 3). Self-reported screen time was significantly associated with the incidence of NSP ($b = 1.88$, $se = 0.81$, $p = 0.020$) between T0–T1, but not between T1–T2 (Table 3).

The interaction of screen time and age with NSP incidence between T0–T1 was significant ($b = -1.85$, $se = 0.83$, $p = 0.027$). However, no association was observed between screen time and NSP incidence between T1–T2 (Table 3). Of the different types of screen time, passive gaming time ($b = 2.75$, $se = 1.31$, $p = 0.036$) and social media time ($b = 1.71$, $se = 0.75$, $p = 0.023$) were significantly associated with NSP incidence among the children between T0–T1 (Table 3), but not between T1–T2 (Table 3).

Discussion

The incidence of NSP was 15% among all at the end of the first follow-up year and 18% at the end of the second follow-up year. Accelerometer-measured MVPA and ST were not associated with the weekly incidence of NSP, but self-reported screen time, especially time spent in social media and passive gaming, were associated with the incidence of NSP in children at the end of the first follow-up year.

This study is among the first to investigate the prospective associations of the incidence of NSP with accelerometer-measured MVPA and ST in school-aged children. Although the previous cross-sectional studies might lead one to expect that PA would associate with NSP incidence in children[8,9,28], no such association was found. In support, two previous accelerometer-based studies, differed in some respects from ours, also found no association between PA and the incidence or prevalence of NSP. In the study by Wedderkopp et al. (2009) of 9-year-olds (n = 256), the odds for having neck pain three years later did not increase significantly at any PA level, although higher PA was preventive for lower and mid back pain[29]. Participants who developed spinal pain three years later were compared on their baseline PA. Thus, no PA intervention was conducted. In addition, the follow-up was longer than in our study, which means that pain can vary widely without researchers being able to trace it, while the recall period for spinal pain (neck pain, middle back pain, and lower back pain) in a structured interview was shorter at just 1 month[29]. Aartun et al. (2016) also found no cross-sectional or longitudinal associations between accelerometer-measured PA and spinal pain (neck pain, mid back pain, low back pain) in their follow-up data on 11- to 15-year-old adolescents[12]. The biggest difference between their study and ours was that, owing to pain overlap, they collapsed the three spinal areas into one. Therefore, an association between PA and NSP alone was not available for comparison with our results. Moreover, they did not attempt to elucidate the causal relationship, but only the relationship between spinal pain and PA[12]. Franz et al. (2017) reported the intensity of the PA to have an association to spinal pain overall in children 6–12 years of age (n = 1205) in their longitudinal study[30]. The shift from sedentary activity to vigorous PA was associated with increased occurrences of spinal pain and

	Year	ALL Mean (sd)	N	BOYS Mean (sd)	N	GIRLS Mean (sd)	N	*p* (boys/girls)
Age (years)	T0	12.5 (1.3)	970	12.6 (1.3)	462	12.5 (1.3)	507	0.605
BMI (kg/m2)	T0	18.9 (3.2)	914	18.6 (3.3)	429	19.1 (3.2)	485	0.054
Bedtime (23.00 or later)	T0	54 (5.7)	947	24 (5.3)	451	30 (6.0)	496	0.630
Injury at spinal area (%)	T0	81 (8.6)	947	45 (10.0)	451	36(7.3)	496	0.135
NECK AND SHOULDER PAIN NSP total, range 1–5*	T0	2.0 (1.1)	905	1.9 (1.0)	430	2.0 (1.1)	475	0.110
	T1	1.8 (1.0)	847	1.7 (0.9)	400	2.0 (1.1)	447	< 0.001
	T2	1.9 (1.1)	780	1.8 (1.0)	369	2.1 (1.1)	411	< 0.001
NSP (at least once/week) (%)	T0	235(26)	905	99(23)	430	133(28)	475	0.091
	T1	195(23)	847	68(17)	400	125(28)	447	< 0.001
	T2	211(27)	780	78(21)	369	127(31)	411	0.001
NSP incidence %	T0–T1	91(15)	605	32(11)	294	59(19)	311	0.006
	T1–T2	105(18)	586	47(16)	295	58(20)	291	0.207
ACCELEROMETER-MEASUREMENTS MVPA (min/day)	T0	52.7 (21.7)	767	59.2 (23.7)	342	47.5 (18.4)	425	< 0.001
	T1	51.5 (22.6)	503	57.8 (25.0)	209	47.1 (19.5)	294	< 0.001
	T2	45.2 (19.1)	319	47.1 (19.8)	127	43.9 (18.5)	192	0.145
ST10min (h/day)	T0	3.7 (1.2)	767	3.5 (1.3)	342	3.8 (1.2)	425	0.003
	T1	4.1 (1.3)	503	3.9 (1.3)	209	4.3 (1.3)	294	0.007
	T2	4.8 (1.4)	319	4.8 (1.4)	127	4.8 (1.3)	192	0.817
SELF-REPORTED SCREEN TIME Screen time (h/day)	T0	4.2 (2.8)	948	4.5 (3.1)	451	4.0 (2.5)	497	0.002
	T1	4.7 (3.0)	868	5.2 (3.2)	411	4.3 (2.7)	457	< 0.001
	T2	5.0 (3.1)	798	5.4 (3.1)	381	4.6 (3.1)	417	< 0.001
TV time (h/day)	T0	1.8 (1.2)	948	1.9 (1.2)	451	1.7 (1.1)	497	0.088
	T1	1.9 (1.3)	868	2.1 (1.3)	411	1.8 (1.2)	457	0.002
	T2	2.0 (1.3)	798	2.1 (1.3)	381	1.9 (1.2)	417	0.020
Games (h/day)	T0	1.3 (1.3)	948	1.8 (1.4)	451	1.0 (1.0)	497	< 0.001
	T1	1.2 (1.3)	868	1.8 (1.5)	411	0.7 (0.9)	457	< 0.001
	T2	1.2 (1.5)	798	2.0 (1.6)	381	0.5 (1.0)	417	< 0.001
Social media (h/day)	T0	1.1 (1.2)	948	0.9 (1.2)	451	1.3 (1.3)	497	< 0.001
	T1	1.6 (1.6)	868	1.3 (1.5)	411	1.8 (1.7)	457	< 0.001
	T2	1.8 (1.7)	798	1.3 (1.5)	381	2.3 (1.8)	417	< 0.001

Table 1. Study variables for all participants and for boys and girls separately at T0, (2013), T1 (2014) and T2 (2015). BMI = Body mass index; *response options 1 = rare or never, 2 = about once a month, 3 = once a week, 4 = more than once a week, 5 = almost daily; ST = Sedentary time, MVPA = Moderate to vigorous physical activity; *p* value for gender difference (Student's t-test or Pearson's chi-squared test).

the shift from sedentary to moderate intensity activity appeared to protect against spinal pain[30]. However, the NSP was not separately reported but the pains of the spinal area. Another difference compared to our study was, that the children did not report their pain themselves, but the parents of the children provided the information.

The analysis of self-reported screen time showed an association of overall screen time and time spent in passive gaming and in social media with the incidence of NSP in children during the first follow-up year. For example, one additional hour of screen time per day was associated with a 3.79 -fold increase in the incidence of NSP. Screen time, often thought of as sedentary, can be active, as in the case of exergaming or active mobile games, which were excluded from the analyzed questions describing sedentary behavior and screen time in our study. Clearly, the use of portable smart devices does not always require gaming to meet the active time criterion. Our finding that self-reported screen time was associated with NSP during the first but not the second follow-up year might be partly explained by the development of the children. For example, the use of mobile phones by children and adolescents has been reported to be predominantly a social recreation (73%), and children under the age of 15 appear to have more difficult giving up media devices than older children[31]. This may also be due to the increased awareness of older children about their negative relationship with the media device[31]. Ståhl et al. (2008) have also found fluctuation in neck pain in children[6].

A recent study found that the use of mobile touch screen device increased the odds for NSP in 10- to 19-year-olds at follow-up one year later, while no association was found between the duration of screen time and NSP[32]. In a Chinese study, also on older adolescents, the use of tablets significantly increased the incidence of NSP[33]. These results suggest that it is important to consider what devices are being used when seeking to understand the association of device use with musculoskeletal symptoms[32]. Bending the upper body over cell phones and other portable devices can lead to increased stress on cervical spine, which in turn can lead to cervical degeneration and other developmental, medical, psychological, and social complications[34].

ALL	NSP			NSP prevalence (at least once a week)			incidence	
	T0	T1	T2	T0	T1	T2	T0–T1	T1–T2
MVPA								
T0	−0.056	−0.109**	−0.108**	−0.078*	−0.090*	−0.099*	−0.072	−0.037
T1	−0.011	−0.058	−0.086	−0.038	−0.049	−0.080	−0.079	−0.055
T2	−0.017	−0.047	−0.012	−0.034	−0.028	−0.071	−0.019	0.002
ST10min								
T0	0.061	0.126**	0.086*	0.061	0.109**	0.048	0.093*	−0.008
T1	0.038	0.127**	0.163**	0.040	0.102*	0.147**	0.118*	0.105
T2	−0.005	−0.036	0.028	0.011	−0.023	0.080	−0.008	0.106
Screen time								
T0	0.129**	0.078*	0.101**	0.117**	0.070*	0.104**	0.052	0.052
T1	0.079*	0.116**	0.092*	0.074*	0.097**	0.099**	0.073	0.047
T2	0.088*	0.090*	0.114**	0.126**	0.070	0.101**	0.055	0.098*
TV time								
T0	0.031	0.019	0.048	0.035	0.021	0.059	0.001	−0.016
T1	0.000	0.030	0.031	0.007	0.024	0.031	0.004	0.001
T2	0.031	0.053	0.071*	0.074*	0.056	0.078*	0.007	0.059
Games								
T0	0.112**	0.011	−0.012	0.101**	0.018	0.002	0.010	0.005
T1	0.028	−0.009	−0.067	0.016	0.013	−0.042	−0.019	−0.039
T2	0.024	−0.046	−0.041	0.042	−0.033	−0.042	−0.014	0.011
Social media								
T0	0.146**	0.148**	0.199**	0.126**	0.120**	0.182**	0.109**	0.132**
T1	0.119**	0.194**	0.196**	0.116**	0.147**	0.188**	0.149**	0.120**
T2	0.114**	0.165**	0.190**	0.136**	0.114**	0.162**	0.107*	0.128**

Table 2. Pearson correlation coefficients between variables and neck and shoulder pain (NSP) at T0, T1 and T2 for all participants. * $p < 0.04$, ** $p < 0.05$, MVPA = Moderate to vigorous physical activity (≥ 2296 cpm); ST10min = sedentary time of at least 10 min (< 100 cpm).

A recent Finnish national report (n = 3408) found that problematic 11-, 13- and 15-year-old users of social media (9.4%) suffered twice as much from NSP and headaches than non-problematic users[18]. The problematic social media prevalence was 9.4% and the moderate risk prevalence 33.5%. Problematic use was more prevalent among older users (11.2% in 13- and 15-year-olds, 5.9% in 11-year-olds) and parental monitoring was significantly associated with a lower prevalence of moderate risk and problematic social media use[18].

The major strengths of the current study were the prospective setting, large sample size, accelerometer-measured PA and ST, and utilization of a well repeatable web-based questionnaire which yields broader information on the context of our study population's sedentary behavior[35]. Accelerometer-measurements are considered more reliable than self-reports as a measure of activity levels among children[33]. Estimating PA solely with a questionnaire can lead to overestimation of the higher levels of PA and to recall errors[29]. Likewise, it is possible that accelerometers underestimate PA because they fail to reliably detect some forms of PA, such as cycling or strength training, and cannot be used in water-related activities. To eliminate the effects of seasonal variation, the measurements were performed at the same time of year. As a weakness of the study can be mentioned self-reporting for both NSP and screen time variables. The limited use of accelerometers of 7 days based on study design maybe not correspond to a person's normal physical activity and a typical week in that respect.

As a conclusion, accelerometer-measured PA and ST were not associated with the incidence of NSP in school-aged children at the two-year follow-up. However, self-reported screen time, particularly for the passive gaming and social media use, was associated with NSP incidence at the one-year follow-up. This finding has a novelty value, as the factors that may be important in the recognizing significant NSP problem in school-aged children have now been studied longitudinally. We showed, that screen time at least partially affects children's NSP symptoms. Time spent in physical activities, in passive gaming and in social media, may compete for children's use of time, which highlights the role of physical activity in supporting children's health and well-being. Children with symptoms of NSP may benefit from an assessment of PA and screen time habits.

Finally, in terms of screening time, there is a need to look deeper into the effects, to find information about the different types and contents that can affect the NSP of school-aged children. Research needs to be done specifically to help parents and other adults who are responsible with guiding our school-aged children to the healthy use of technology and understanding the potential disadvantages of that. We may never be able to completely prevent school-aged children's NSP but we need to understand it, to act consciously to reduce the risk of NSP. Therefore, mechanisms underlying NSP in relation to screen time should be further investigated to develop effective preventive actions for NSP during childhood.

	NSP incidence T0–T1				NSP incidence T1–T2			
	b (se)	OR	95%CI	*p* value	b (se)	OR	95%CI	*p* value
MVPA								
MVPA	− 1.05 (0.81)	0.91	0.79–1.05	0.195	0.98 (0.92)	1.08	0.94–1.25	0.283
MVPA × gender	0.01 (0.22)	1.00	0.97–1.03	0.947	− 0.08 (0.16)	1.00	0.98–1.01	0.604
MVPA × age	1.01 (0.75)	1.01	1.00–1.02	0.174	− 0.90 (0.86)	0.99	0.98–1.01	0.295
Bedtime (23.00 or later)	0.13 (0.05)	4.39	1.75–11.04	0.005	0.09 (0.05)	1.89	0.88–4.08	0.102
Gender*	0.13 (0.24)	1.66	0.29–9.54	0.569	0.19 (0.18)	2.02	0.53–7.74	0.300
BMI	0.00 (0.07)	1.00	0.92–1.08	0.968	− 0.06 (0.07)	0.96	0.89–1.04	0.344
Age	− 0.12 (0.21)	0.83	0.44–1.57	0.564	0.33 (0.21)	1.67	0.89–3.11	0.106
Injury	0.01 (0.04)	1.14	0.47–2.75	0.772	0.13 (0.05)	3.38	1.35–8.44	0.008
ST10min								
ST10min	1.02 (0.77)	5.11	0.43–60.20	0.187	− 0.26 (0.84)	0.68	0.05–8.50	0.762
ST10min × gender	− 0.07 (0.26)	0.94	0.57–1.54	0.791	− 0.25 (0.29)	0.81	0.50–1.31	0.392
ST10min × age	− 1.00 (0.81)	0.89	0.74–1.07	0.219	0.36 (1.01)	1.04	0.85–1.28	0.721
Bedtime (23.00 or later)	0.12 (0.05)	3.73	1.53–9.08	0.009	0.07 (0.05)	1.69	0.84–3.42	0.140
Gender*	0.22 (0.26)	2.28	0.31–16.60	0.412	0.33 (0.27)	3.40	0.45–25.51	0.228
BMI	0.01 (0.07)	1.00	0.93–1.09	0.928	− 0.09 (0.07)	0.95	0.87–1.03	0.232
Age	0.34 (0.21)	1.72	0.88–3.36	0.106	0.06 (0.29)	1.09	0.46–2.59	0.841
Injury	0.02 (0.04)	1.21	0.49–3.01	0.678	0.12 (0.05)	2.94	1.19–7.30	0.018
Screen Time								
Screen Time	1.88 (0.81)	3.79	1.37–10.47	**0.020**	− 0.75 (0.69)	0.61	0.26–1.47	0.272
Screen Time × gender	− 0.07 (0.10)	0.94	0.79–1.12	0.502	0.06 (0.11)	1.04	0.90–1.20	0.605
Screen Time × age	− 1.85 (0.83)	0.90	0.83–0.98	0.027	0.76 (0.66)	1.04	0.97–1.11	0.254
Bedtime (23.00 or later)	0.09 (0.04)	2.80	1.27–6.20	0.018	0.08 (0.05)	1.74	0.86–3.53	0.124
Gender*	0.24 (0.12)	2.51	0.98–6.43	0.050	0.06 (0.12)	1.26	0.51–3.10	0.614
BMI	0.00 (0.06)	1.00	0.93–1.08	0.945	− 0.07 (0.07)	0.96	0.88–1.04	0.303
Age	0.36 (0.11)	1.78	1.26–2.53	0.001	0.03 (0.11)	1.04	0.75–1.46	0.809
Injury	0.02 (0.04)	1.33	0.54–3.26	0.539	0.12 (0.05)	2.95	1.21–7.18	0.016
TV								
TV	0.87 (0.58)	4.45	0.68–29.04	0.132	− 0.86 (0.72)	0.28	0.03–2.32	0.233
TV × gender	− 0.09 (0.11)	0.85	0.57–1.27	0.424	0.09 (0.12)	1.14	0.81–1.61	0.451
TV × age	− 0.84 (0.59)	0.89	0.77–1.04	0.157	0.77 (0.69)	1.09	0.93–1.28	0.264
Bedtime (23.00 or later)	0.11 (0.04)	3.34	1.44–7.73	0.010	0.08 (0.05)	1.81	0.87–3.78	0.110
Gender*	0.23 (0.12)	2.41	0.95–6.12	0.059	0.04 (0.12)	1.16	0.47–2.81	0.750
BMI	0.01 (0.07)	1.00	0.93–1.09	0.925	− 0.07 (0.07)	0.96	0.88–1.04	0.349
Age	0.26 (0.10)	1.51	1.08–2.09	0.013	0.03 (0.12)	1.04	0.73–1.49	0.812
Injury	0.01 (0.04)	1.19	0.50–2.82	0.698	0.13 (0.05)	3.15	1.28–7.72	0.012
Games								
Games	2.75 (1.31)	5.79	1.08–30.99	**0.036**	− 0.68 (0.56)	0.37	0.08–1.84	0.226
Games × gender	− 0.18 (0.22)	0.94	0.79–1.10	0.419	− 0.15 (0.08)	0.67	0.45–1.00	0.050
Games × age	− 0.20 (0.10)	0.19	0.04–1.00	0.046	0.69 (0.53)	1.08	0.96–1.22	0.191
Bedtime (23.00 or later)	1.06 (0.39)	1.10	1.02–1.18	0.007	0.08 (0.05)	1.76	0.88–3.51	0.110
Gender*	0.92 (0.40)	1.27	1.04–1.55	0.021	0.18 (0.10)	1.94	0.90–4.16	0.085
BMI	0.00 (0.04)	1.01	0.89–1.13	0.930	− 0.08 (0.07)	0.95	0.88–1.03	0.249
Age	0.44 (0.16)	1.31	1.09–1.59	0.006	0.07 (0.07)	1.12	0.91–1.38	0.291
Injury	0.22 (0.45)	1.02	0.95–1.09	0.627	0.12 (0.05)	2.94	1.17–7.39	0.020
Social media								
Social media	1.71 (0.75)	17.71	1.62–193.1	**0.023**	0.34 (0.70)	1.53	0.27–8.57	0.630
Social media × gender	0.00 (0.09)	0.99	0.69–1.43	0.973	0.08 (0.10)	1.11	0.86–1.44	0.435
Social media × age	− 1.66 (0.75)	0.81	0.67–0.97	0.027	− 0.29 (0.69)	0.97	0.85–1.11	0.675
Bedtime (23.00 or later)	0.09 (0.04)	2.81	1.34–5.91	0.012	0.06 (0.05)	1.57	0.74–3.32	0.237
Continued								

	NSP incidence T0–T1				NSP incidence T1–T2			
	b (se)	OR	95%CI	*p* value	b (se)	OR	95%CI	*p* value
Gender*	0.17 (0.09)	1.88	0.94–3.73	0.067	0.04 (0.09)	1.17	0.61–2.24	0.632
BMI	0.00 (0.07)	1.00	0.92–1.08	0.978	− 0.09 (0.08)	0.95	0.87–1.04	0.248
Age	0.23 (0.07)	1.44	1.15–1.80	0.001	0.12 (0.09)	1.21	0.93–1.56	0.149
Injury	0.03 (0.04)	1.37	0.56–3.34	0.493	0.12 (0.05)	2.90	1.16–7.23	0.020

Table 3. Results of logistic regression analyses on incidence of neck and shoulder pain (NSP) in relation to independent variables in models. Variables at measurement point T0 or T1 predicting NSP incidence at next follow-up period (T0–T1 or T1–T2). *0 = boy, 1 = girl. Models are adjusted by bedtime (23.00 or later), BMI (body mass index) and spinal injuries; b = standardized regression coefficient; se = standard error. Significant values are in bold.

Data availability

The data that support the findings of this study are available from [LIKES] but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of [LIKES].

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Author contributions
Doctoral Researcher Pirnes has been the corresponding author of this article and she is responsible for literature search and writing and interpreting the study data. PhD J.J.K, PhD H.H., PhD A.H., PhD A.H.H., PhD T.T. have all been involved in planning the study design together with the corresponding author. They all have been involved also in the writing process, correcting, reflecting and reviewing study phases in both text and data analysis. MSc H.H. has been responsible for the statistical analysis procedure.

Competing interests
The authors declare no competing interests.

Additional information
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IV

PHYSICAL FITNESS CHARACTERISTICS AND NECK AND SHOULDER PAIN INCIDENCE IN SCHOOL-AGED CHILDREN—A 2-YEAR FOLLOW-UP

by

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Physical fitness characteristics and neck and shoulder pain incidence in school-aged children—A 2-year follow-up

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Abstract

Background and Aims: Neck and shoulder pain (NSP) is common in school age, but preventative factors have not been identified. The purpose was to study whether a fitness test could be used to predict the incidence of NSP and determine whether good physical fitness characters would be associated with lower NSP incidence in school-aged children at 2-year follow-up.

Methods: After the invitation to nine schools, 970 children (10–15 years old) agreed to participate. Flexibility, fundamental movement skills, musculoskeletal fitness, and cardiorespiratory fitness measurements included in Finnish Schools on the Move! monitoring system for physical functional capacity were measured at baseline in 2013. The NSP incidence was assessed by an online survey during school hours after 1 and 2 years. Logistic regression was used to analyze associations between physical fitness characteristics and NSP incidence.

Results: The mean prevalence of NSP was 26% at baseline. The NSP incidence was 15% in the first and 18% in the second follow-up year. Good physical fitness was not associated with lower NSP incidence in the 2-year follow-up. Successful lower back extension (odds ratio [OR] = 2.83) and good scores in curl-up (OR = 1.80) adjusted with age, gender, and body mass index, were associated with higher NSP incidence between T0 and T2. Throwing–catching combination (OR = 0.55) was associated with a lower NSP incidence in unadjusted analysis, but the association did not remain after adjustments.

Conclusion: Good physical fitness characteristics were not consistently associated with a lower NSP incidence in school-aged children in a 2-year follow-up. The role of general field-based physical fitness test as a screening tool for NSP incidence remains unconfirmed. More longitudinal studies are needed to detect the factors underlying NSP incidence in school-aged children.

KEYWORDS
neck and shoulder pain incidence, physical fitness characteristics, school-aged children

1 | INTRODUCTION

Despite the global improvement of the overall health between 1990 and 2019, musculoskeletal disorders in general have an ascending trend.[1] Nevertheless, neck and shoulder pain (NSP) in school-aged children has become a serious, growing problem that might lead to potential health-related problems at early adulthood.[2] NSP have been found to be persistent in nature[3] and some evidence suggests that adolescents with neck symptoms are at higher risk of developing NSP in adulthood.[4] However, the prognostic factors behind the increasing incidence of NSP have not been adequately studied in school-aged children. Since general physical fitness measurements are widely used in schools, the usefulness of the information obtained from them in health education and health monitoring should be investigated in front of growing health issues that NSP now is.

There are no longitudinal studies on the role of childhood/adolescent physical fitness on the incidence of NSP. Longitudinal studies in adults have not found clear associations between physical fitness characteristics and NSP, while associations between physical fitness and other factors such as social support or work-related factors have been found.[5–7] Some longitudinal studies have reported interesting associations between physical fitness and NSP incidence from childhood to adulthood.[8,9] The results of a 25-year study on predictive values of measured fitness characteristics to adult pain conditions showed, that boys in the best tertile of flexibility had the least tension neck symptoms as adults, while girls in the best flexibility tertile were most likely to have tension neck symptoms as adults.[9] Additionally, good performance in bench press at the age of 16 has been reported to be associated with a lower risk for neck–shoulder symptoms among men.[8]

Musculoskeletal health is, for example, according to the Toronto model, one factor closely related to health-related fitness[10] and therefore the interactions should be carefully studied. Plowman et al. (2014) have emphasized the importance of longitudinal physical fitness studies performed only in children and adolescents to find associations between potential health risk factors and valid, reliable field tests.[11] This is justified because the philosophy of physical fitness testing for adolescents has changed from performance-based to health-based assessment a few decades ago.[12] Current studies in children and adolescents are mainly in cross-sectional settings, but based on them, good physical characteristics might be negatively associated with NSP.[13–15]

Physical fitness measurements should be able to measure the range from limited function to high capacity and accurately reflect the characteristics of the child's physical fitness.[12] Measurements should also take into account the possible effects of modifying factors such as age, sex, and body composition on the associations studied.[12] All these factors have been considered in the present study design. Because the effects of fitness characteristics on the incidence of NSP in school-aged children are not well known, we tested a hypothesis in which good physical fitness would be associated with a lower incidence of NSP in school-aged children during the 2-year follow-up. To assess this, we utilized the field-based fitness measurements included in the Finnish national Move! monitoring system for physical functional capacity aimed for school-aged children.

2 | MATERIALS AND METHODS

2.1 | Participants

This study is part of the larger research project linked to national “Finnish Schools on the Move” program[16–20] and a total of 1710 school-aged children in grades 4–7 from nine public schools across Finland were invited to participate in a longitudinal study (2013–2015). Of these children, 970 participated (mean 12.5 years ± 1.3 years; 52.5% girls) and 684 (75.6%) provided information on all the study variables at baseline. After excluding children who reported NSP due to spinal injuries, the final sample of this cohort comprised 905 10–15-year-old children. 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).

2.2 | Measurements

The participants filled in a web-based questionnaire in spring 2013, 2014, and 2015. The test–retest repeatability of the NSP questionnaire has been reported to be substantial (Kappa [κ] value 0.68 for the 2-point scale and intraclass correlation coefficient [ICC] 0.67 for the 5-point scale).[19] Data on children's NSP were collected with a question that illustrates pain in the last 3 months before the study: “How often have you had symptoms in the last three months”? The children chose the appropriate frequency and selected areas of the body, such as “neck or shoulder pain or ache,” from the list. The answer options were selected from five categories: (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 figure of the human body with zones and written names of the corresponding body areas to ensure that the different body regions were understood correctly. Participants were allowed to ask for help in completing the questionnaire from an adult in the class.

For the analysis of the incidence, the answers regarding NSP symptoms during last 3 months were grouped into two categories: (1) once a week or more often and (2) less than once a week. The pupils were also asked if they had had pain originated from a trauma. Children who reported trauma in the neck and shoulder area ($n = 42$) were excluded in the analysis. The incidence of NSP in this study refers to new cases, where pain was reported as occuring at least once a week during the past 3 months.

Measurements of physical fitness characteristics at baseline were included. These measurements are part of the national Move! monitoring system for a physical functional capacity which is implemented in the physical education curriculum of Finnish fifth and eighth-grade children.[21] The main purpose of the use of this instrument in schools is to encourage children to independently take care of their physical functional capacity. The measured physical fitness characteristics are flexibility, muscular fitness, fundamental movement skills, and cardiorespiratory fitness.

Flexibility indicates the ability to move freely throughout the range of motion of joints.[11] Flexibility[21] was measured by four tasks consisting of multijoint flexibility measurements; lower back extension in sitting posture, squat, and right and left shoulder stretch. The tasks were evaluated according to the selected criteria (0= did not succeed, 1 = succeeded).

Muscular fitness reflects the ability to work against resistance[22] and it was assessed with push-up and curl-up measurements. Push-up[23,24] measures upper body strength. Boys performed push-ups with hands and toes and girls with hands and knees on the ground. The children repeated the movement as many times as possible in 1 min time and only correctly performed repetitions were recorded. Curl-up[25,26] is a modified version of the FitnessGram curl-up and the number of correct repetitions was calculated with a maximum of 75 repetitions.

Fundamental movements skills (FMS) representing neuromotor skills include balance, coordination, gait, agility, and proprioceptive skills[27] and were assessed with five-leap and throwing–catching combination tests. In the five-leap test,[25] children tried to jump as far as possible with five consecutive jumps. The first leap was strained with both feet, followed by four alternating one-foot leaps forward and the last leap ending on both feet. Best performance out of two attempts was recorded in meters to the nearest 0.1 m.

In the throwing–catching combination test,[21] a tennis ball was thrown from 7 to 10 m distance (a distance selected for age and sex) to a 1.5 m × 1.5 m target area on the wall, 0.9 m above the floor. A successful throw-catch combination included hitting the target area behind the marked line and grabbing the ball after one bounce. The number of successful throwing–catching combinations was counted.

Cardiorespiratory fitness represents the total capacity of the cardiovascular and respiratory organs and enables to carry out physically demanding tasks for a prolonged period of time.[22] Cardiorespiratory fitness was estimated with the performance of the 20-m shuttle run test where running speed is increased in 1-min interval until maximal voluntary exhaustion. Initial speed was 8.0 km h^{-1}, following speed 9.0 km h^{-1}, and following increment of 0.5 km h^{-1} per stage.[28] The result was counted as the number of laps run.

Measurements were performed by group of four to six educated research personnel, in the children's own school sports facilities. One group at a time (average 25 children) participated in the measurements during 1.5 h. Measurement techniques were explained to the participants and practiced before the formal evaluation. The test scores were recorded by the research staff.[16]

Each pupil's weight and height were measured and used to calculate the body mass index (BMI, kg · m^{-2}). Weight was measured in light clothing using bioelectrical impedance analysis (InBody 720, Biospace Co., Ltd). For measuring the height, a portable Charder HM 200 P measuring instrument was used. The measurement was done 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 used in the analysis.

2.3 | Data analysis

Move! results at baseline (T0) and one-year measurement point (T1) and the self-reported weekly prevalence and incidence of NSP at three measurement points (T0, T1, and T2) were analyzed. The incidence of NSP was observed between T0 and T2, but also between T0–T1 and T1–T2. The data are presented as means, standard deviations (SD), and percentages.

The incidence of NSP refers to new cases, where pain was perceived at least once a week during past 3 months. The variable of NSP incidence received a value 0 if the participant still experienced NSP less than once a week (reference category) in the 1-year follow-up. If more frequent NSP were observed compared with the reference category, NSP incidence variable received a value 1. Children with NSP at least once a week already at baseline were not included in the analysis.

The unequal probabilities of selection (by age and gender) were taken into account by using sampling weights in the modeling. Using information on population structure obtained from Official Statistics of Finland,[29] sampling weights were constructed. Parameters of the models were estimated by using full information maximum likelihood method (FIML)[30] with robust standard errors (MLR). Missing data were assumed to be missing at random (MAR). Because data were clustered within schools and ages, standard errors were calculated by using special feature of Mplus (TYPE = COMPLEX).

For logistic regression analysis, Move! results in different physical fitness characteristics were classified as good (Tertile 3), followed by moderate (Tertile 2) and low (Tertile 1) in scores. Tertiles were as uniform in size as possible and were standardized by age and gender to prevent weighted result. The results were analyzed without adjustments (Model 1) and with age, gender, and BMI adjustments (Model 2) and the comparison was performed against to the Tertile 1. In the analysis of the flexibility measurements, tertiles were not needed since the variable was already dichotomous (did not succeed/succeeded) and the comparison was performed against a failed performance.

The dropouts were taken into account by using the FIML[30] in the analyses, which means the model was corrected with a missing value. The analyzes were made by using SPSS 25.0 for Windows (SPSS Inc.) and Mplus 7.0 using a 5% significance level. p values ≤ 0.05 indicated a significant association.

3 | RESULTS

3.1 | Description of study population

Table 1 shows the characteristics of the participants and the differences between boys and girls. The mean prevalence of NSP

TABLE 1 The characteristics for all the participants, boys, and girls and the differences between boys and girls

	Grade	TOTAL		BOYS		GIRLS		*p*
		N	Mean (sd)	*N*	Mean (sd)	*N*	Mean (sd)	(boys/girls)
Age (y)		970	12.5 (1.3)	462	12.6 (1.3)	507	12.5 (1.3)	0.605
BMI (kg · m^2)		914	18.9 (3.2)	429	18.6 (3.3)	485	19.1 (3.2)	0.054
NSP total		905	2.0 (1.1)	430	1.9 (1.0)	475	2.0 (1.1)	0.110
NSP (at least once a week)		905	26%	430	23%	475	28%	0.091
NSP incidence T0–T1		605	15%	294	11%	311	19%	0.006
NSP incidence T1–T2		586	18%	295	16%	291	20%	0.207
Squat	4	207	89%	98	86%	109	92%	0.168
	5	157	94%	63	92%	94	95%	0.510
	6	164	92%	89	89%	75	96%	0.087
	7	382	92%	179	89%	203	94%	0.138
	TOT	910	91%	429	89%	481	94%	0.008
Lower back extension	4	207	72%	98	62%	109	82%	0.002
	5	157	80%	63	67%	94	88%	0.001
	6	164	79%	89	72%	75	87%	0.022
	7	382	81%	179	75%	203	87%	0.005
	TOT	910	79%	429	70%	481	86%	<0.001
Shoulder strech/Right	4	207	88%	98	95%	109	82%	0.003
	5	157	89%	63	92%	94	86%	0.256
	6	164	93%	89	92%	75	95%	0.518
	7	381	89%	179	92%	202	86%	0.091
	TOT	909	89%	429	93%	480	86%	0.003
Shoulder strech/Left	4	207	59%	98	53%	109	64%	0.103
	5	157	66%	63	60%	94	69%	0.254
	6	164	60%	89	49%	75	72%	0.003
	7	382	69%	179	54%	203	82%	<0.001
	TOT	910	64%	429	54%	481	74%	<0.001
Push-up	4	197	16.6 (12.7)	96	13.1 (12.4)	101	19.9 (12.1)	<0.001
	5	155	19.5 (12.6)	62	13.9 (9.6)	93	23.2 (13.1)	<0.001
	6	158	19.3 (11.0)	83	17.0 (11.5)	75	21.7 (9.9)	0.007
	7	367	23.5 (13.5)	172	19.5 (11.5)	195	27.1 (14.2)	<0.001
	TOT	877	20.5 (13.0)	413	16.7 (11.7)	464	23.9 (13.2)	<0.001
Curl-up	4	205	29.8 (19.0)	97	29.2 (19.2)	108	30.4 (18.9)	0.637
	5	157	41.3 (21.9)	63	41.6 (22.3)	94	41.2 (21.9)	0.910
	6	161	41.4 (20.8)	88	42.6 (20.8)	73	39.8 (20.7)	0.391
	7	373	37.2 (19.6)	177	42.8 (19.8)	196	32.1 (18.0)	<0.001
	TOT	896	37.0 (20.5)	425	39.5 (21.0)	471	34.7 (19.9)	<0.001
Throwing–catching combination	4	206	9.5 (4.8)	98	10.3 (4.9)	108	8.8 (4.6)	0.030
	5	156	12.1 (5.4)	63	13.4 (5.4)	93	11.2 (5.2)	0.009
	6	164	14.1 (4.5)	89	14.6 (4.8)	75	13.5 (4.1)	0.128

TABLE 1 (Continued)

	Grade	TOTAL N	TOTAL Mean (sd)	BOYS N	BOYS Mean (sd)	GIRLS N	GIRLS Mean (sd)	p (boys/girls)
	7	375	12.4 (4.4)	177	12.6 (4.5)	198	12.3 (4.2)	0.495
	TOT	901	12.0 (4.9)	427	12.6 (5.0)	474	11.5 (4.8)	<0.001
5-leap	4	204	7.4 (0.9)	97	7.5 (0.9)	107	7.4 (0.9)	0.463
	5	154	7.9 (1.0)	63	8.2 (0.9)	91	7.7 (1.0)	0.003
	6	157	8.2 (1.0)	83	8.4 (1.1)	74	8.1 (0.8)	0.089
	7	367	8.8 (1.1)	173	9.2 (1.1)	194	8.4 (0.9)	<0.001
	TOT	882	8.2 (1.1)	416	8.5 (1.2)	466	8.0 (1.0)	<0.001
20-m shuttle run	4	206	34.7 (16.3)	98	37.6 (17.6)	108	32.1 (14.6)	0.015
	5	152	40.3 (17.6)	63	47.5 (18.4)	89	35.3 (15.1)	<0.001
	6	158	42.4 (19.8)	84	47.3 (22.3)	74	36.9 (14.7)	<0.001
	7	355	46.5 (19.1)	165	53.4 (19.4)	190	40.6 (16.7)	<0.001
	TOT	871	41.9 (18.9)	410	47.5 (20.3)	461	37.0 (15.9)	<0.001

Note: NSP total, range 1–5*: mean answer: 1, rare or never; 2, about once a month; 3, once a week; 4, more than once a week; 5, almost daily.
Abbreviations: BMI, body mass index; NSP, neck and shoulder pain.

TABLE 2 Logistic regression analysis between flexibility and neck and shoulder pain incidence in school-aged children during 2-year follow-up

Incidence			Lower back extension OR	95% CI	*p*	Squat OR	95% CI	*p*	Shoulder strech/Right OR	95% CI	*p*	Shoulder strech/Left OR	95% CI	*p*
		No	1	1	-	1	1	-	1	1	-	1	1	-
T0–T2	Model 1	Yes	3.30	1.49–7.28	**0.003**	2.48	0.82–7.52	0.107	1.43	0.59–3.44	0.431	1.36	0.79–2.36	0.267
	Model 2	Yes	2.83	1.28–6.25	**0.010**	2.05	0.68–6.21	0.204	1.65	0.67–4.09	0.279	1.18	0.68–2.05	0.560
T0–T1	Model 1	Yes	1.56	0.66–3.68	0.308	0.72	0.34–1.51	0.384	1.43	0.58–3.51	0.436	0.95	0.53–1.70	0.864
	Model 2	Yes	1.30	0.58–2.90	0.524	0.55	0.27–1.13	0.103	1.63	0.70–3.80	0.254	0.83	0.48–1.43	0.499
T1–T2	Model 1	Yes	1.74	0.86–3.54	0.125	1.27	0.37–4.33	0.701	1.79	0.80–3.99	0.155	1.07	0.65–1.77	0.795
	Model 2	Yes	1.65	0.81–3.34	0.166	1.20	0.34–4.22	0.781	1.84	0.81–4.16	0.143	0.99	0.58–1.69	0.962

Note: Statistically significant results are bolded.
Abbreviations: Model 1, crude analysis; Model 2, adjusted with age, gender and BMI (body mass index); No, did not succeed; Yes, succeeded; T0, baseline; T1, first follow-up year; T2, second follow-up year.

at least once a week was 26% among all children at baseline. NSP incidence was an average of 15% between T0 and T1 and 18% between T1 and T2. There was a significant difference in the incidence of NSP between boys and girls between T0 and T1 (p = 0.006) but not between T1 and T2 (p = 0.207). All the physical fitness characteristics together differed between boys and girls (p = 0.008–<0.001), although in the push-up for boys and girls and in the throwing–catching combination test for boys and girls and for different age groups was used a different adjustment in starting position.

3.2 | Associations of flexibility with the NSP incidence

Table 2 presents the associations between the dichotomous (did not succeed/succeeded) flexibility measurements and the incidence of NSP in unadjusted and adjusted (age, gender, and BMI) models at the follow-up points. Successful lower back extension was associated with higher incidence of NSP (OR = 3.30) compared against the failed performances between T0 and T2. The association remained significant after adjustment (OR= 2.83). No other marked associations between the flexibility measurements and the NSP incidence were found.

3.3 | Associations of muscular fitness, fundamental motor skills, and cardiorespiratory fitness with the NSP incidence

Table 3 shows the associations between muscular fitness, fundamental movement skills, and cardiorespiratory fitness and the NSP incidence at the follow-up points. The Tertile 3 with good scores in curl-up had an association with a higher risk of NSP incidence (OR = 1.75) in unadjusted model and when the model was adjusted, the Tertile 2 had an association with a higher risk of NSP incidence (OR = 1.80) compared with the Tertile 1 with low scores at T0–T2. The children in Tertile 3 in throwing–catching combination test, were less likely to get NSP (unadjusted OR = 0.55) compared with children in the Tertile 1 between T0 and T2. However, this association did not remain after adjustments. No other marked associations in follow-up points between these physical fitness characteristics and the NSP incidence were found.

4 | DISCUSSION

NSP is a significant problem at school age, as evidenced by the 26% prevalence and the 15%–18% incidence during the 2-year follow-up presented in this study. We wanted to know whether good scores in a field-based test for physical fitness characteristics would determine lower risk for the incidence of NSP in children. Contrary to our hypothesis, good scores on the physical fitness test did not predict a lower incidence of NSP pain among school-aged children. Instead, successful lower back extension increased the likelihood of NSP by 2.8-fold, and good scores in curl-up increased the likelihood by 1.8-fold. The participants who had good scores in throwing–catching combination test had a 45% lower risk of developing NSP, but the association was not remained after adjustments.

Detecting the associations to the incidence of NSP by measuring physical fitness characteristics can be skewed because the best measurement result does not always require good physical fitness. Someone in very good cardiorespiratory fitness, maybe not succeed in flexibility tasks and someone with poor cardiorespiratory fitness can perform these measurements easily. Such multidirectional associations between physical fitness characteristics and NSP has been reported, for example, Perry et al.[13] in their cross-sectional study for 1608 adolescents. Boys had higher odds for developing NSP when they threw basketball higher and jumped further[13] and girls had higher odds for NSP if they had better abdominal endurance and two-handed dexterity.[13] In addition, the likelihood of pain increased with good back muscle endurance among girls but also with reduced back muscle endurance.[13]

The relationship of fitness characteristics to the incidence of NSP, especially in terms of flexibility, was reported by Mikkelsson et al. in a 25-year follow-up study where the young subjects were 16-year-old at baseline.[9] Flexibility, assessed with sit and reach-test, was found to be associated with a lower likelihood of tension neck symptoms in adulthood in men, while in women, good flexibility was associated with increased tension neck symptoms later in life.[9] In our 1- and 2-year follow-up, flexibility measurements were performed differently than in Mikkelsson et al.[9] study, where the sit and reach-test were used. In addition, they also had a longer follow-up. For these reasons, a more detailed comparison with their study is not justified.

The lower back extension in our study was performed sitting on the floor, legs straight together, and extending the lower back and the squat was performed similarly as an overhead squat by raising and holding arms straight up during the movement. In the shoulder stretch, one hand was reached down over the shoulder and reached behind the back upward with the other hand, trying to touch the fingers together. Although the evidence is not yet clear, flexibility has been used in health-related fitness testing for children and adolescents since the 1980s.[31] It is possible that flexibility may be related to a variety of health issues, such as back pain and injury prevention, but appropriate studies and data are still needed to establish such associations and, for example, to set cut-off values for different flexibility measurements, as other fitness measurements already have.[31]

A previous cross-sectional study in secondary school students suggested that health professionals should use physical fitness assessment as a tool to assess pain intensity.[32] However, in light of current knowledge and our study results we do not support the suggestion of the usefulness of field-based physical fitness testing as a tool to predict the incidence of NSP in school-aged children. If children's NSP continues to grow, it may be necessary to develop a separate assessment tool for NSP that could be used in learning environments alongside the Move! or some other field-based test. It seems, that measurements of general physical fitness do not appear to be sufficient in predicting NSP incidence in school-aged children, but since physical fitness is often measured in schools, learning environments may play an important role in recognizing pain symptoms and promoting children toward an active lifestyle. Move! as a part of the national physical performance monitoring system in Finland, has been included in the school curriculum and designed specifically to support and encourage school-aged children in terms of their physical functioning.[21]

4.1 | Study strengths and limitations

The current study has many strengths such as the prospective setting, large sample size, and a well repeatable web-based questionnaire as a self-report tool.[19] Associations have been studied broadly for different fitness characteristics and not only for one characteristic alone. To eliminate the effects of seasonal variation, the measurements were performed at the same time of year. However, a 2-year follow-up may be too long time to find stable

TABLE 3 Logistic regression analysis between muscular fitness, fundamental movement skills, cardiorespiratory fitness, and NSP incidence in school-aged children during 2-year follow-up

			Push-up			Curl-up			Throwing–catching combination			5-leap			20-m shuttle-run		
Incidence			OR	95% CI	*p*	OR	95% CI	*p*	OR	95% CI	*p*	OR	95% CI	*p*	OR	95% CI	*p*
		Tertile1	1	1	-	1	1	-	1	1	-	1	1	-	1	1	-
T0-T2	Model 1	Tertile2	1.33	0.76–2.32	0.320	1.19	0.66–2.16	0.569	1.06	0.65–1.73	0.822	1.13	0.66–1.91	0.662	1.56	0.83–2.94	0.171
		Tertile3	1.52	0.78–2.98	0.219	1.75	1.01–3.04	**0.048**	0.55	0.31–0.97	**0.038**	1.00	0.59–1.71	0.994	1.08	0.60–1.95	0.791
	Model 2	Tertile2	1.33	0.70–2.53	0.377	1.24	0.65–2.35	0.511	1.09	0.66–1.82	0.729	1.14	0.64–2.02	0.656	1.53	0.79–2.98	0.209
		Tertile3	1.60	0.79–3.24	0.190	1.80	1.02–3.16	**0.042**	0.59	0.34–1.03	0.065	1.05	0.61–1.82	0.853	1.11	0.60–2.07	0.736
T0-T1	Model 1	Tertile2	1.37	0.75–2.50	0.300	0.73	0.36–1.45	0.365	1.13	0.63–2.02	0.675	0.84	0.44–1.60	0.600	1.47	0.74–2.89	0.269
		Tertile3	1.20	0.67–2.17	0.541	1.46	0.76–2.79	0.255	0.68	0.35–1.31	0.244	0.92	0.53–1.61	0.776	0.81	0.40–1.67	0.570
	Model 2	Tertile2	1.39	0.70–2.76	0.343	0.79	0.40–1.56	0.494	1.19	0.67–2.12	0.544	0.85	0.41–1.74	0.648	1.46	0.73–2.93	0.290
		Tertile3	1.25	0.66–2.36	0.492	1.47	0.77–2.83	0.246	0.75	0.39–1.42	0.372	0.97	0.53–1.77	0.925	0.76	0.36–1.63	0.484
T1-T2	Model 1	Tertile2	1.43	0.77–2.67	0.258	1.31	0.745–2.31	0.341	0.97	0.57–1.68	0.925	0.79	0.48–1.30	0.350	1.28	0.68–2.41	0.444
		Tertile3	1.19	0.64–2.21	0.587	1.33	0.73–2.43	0.358	0.85	0.49–1.46	0.547	0.71	0.38–1.33	0.279	1.15	0.55–2.39	0.708
	Model 2	Tertile2	1.39	0.71–2.74	0.339	1.21	0.68–2.16	0.508	0.97	0.55–1.72	0.921	0.76	0.46–1.24	0.269	1.18	0.63–2.22	0.610
		Tertile3	1.09	0.57–2.10	0.788	1.20	0.63–2.29	0.573	0.89	0.52–1.53	0.676	0.68	0.36–1.29	0.239	1.06	0.50–2.23	0.884

Note: Statistically significant results are bolded.

Abbreviations: Model 1, crude analysis; Model 2, adjusted with age, gender and BMI (body mass index); T0, baseline; T1, first follow-up year; T2, second follow-up year; Tertile 1, low scores, a reference category; Tertile 2, moderate scores; Tertile 3, high scores.

associations with NSP incidence in school-aged children, since NSP is fluctuating in nature[33] and the recall time for the NSP was 3 months at the measurement points. The questionnaire may need to be repeated more frequently in future surveys to gain an understanding of, for example, the annual incidence of NSP.

5 | CONCLUSIONS

Although the health benefits of good physical fitness are very clear for growing children, in the present study, good physical fitness characteristics were not associated with lower NSP incidence in 2-year follow-up. Therefore, the evidence does not support the use of field-based fitness measurements as a screening tool for future NSP. As the prevalence and incidence of NSP are considerable high in this age-group, we would like to suggest that in the onset of NSP, the etiology and treatment of the NSP nature would be determined individually for example using expertise offered by a physiotherapist. The inconsistent associations between some fitness characteristics and NSP incidence in this study encourage further research focusing on a broader search for factors underlying the NSP incidence to find preventive tools for school-aged children for possible onset of NSP symptoms.

AUTHOR CONTRIBUTIONS

Katariina P. Pirnes: Conceptualization; formal analysis; methodology; project administration; resources; validation; visualization; writing – original draft; writing – review & editing. **Jouni J. Kallio**: Conceptualization; supervision; validation. **Harto J. Hakonen**: Data curation; formal analysis; software. **Arto J. Hautala**: Conceptualization; supervision; writing – review & editing. **Laura Joensuu**: Conceptualization; supervision; validation; writing – review & editing. **Arja H. Häkkinen**: Conceptualization; supervision; validation; writing – review & editing. **Tuija H. Tammelin**: Conceptualization; data curation; formal analysis; funding acquisition; supervision; validation; writing – review & editing.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

TRANSPARENCY STATEMENT

The correspondent author (Katariina P. Pirnes) of this study, affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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