PUBLICATIONS OF
THE UNIVERSITY OF EASTERN FINLAND

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UNIVERSITY OF EASTERN FINLAND

ANU VIEROLA

PREVALENCE AND DETERMINANTS OF PAIN AND TEMPOROMANDIBULAR DISORDERS IN 6-8 YEAR-OLD CHILDREN

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To be presented by permission of the Faculty of Health Sciences, University of Eastern Finland for public examination in Medistudia auditorium MS302, Kuopio,
on Friday, December 15th 2017, at 12 noon

Publications of the University of Eastern Finland
Dissertations in Health Sciences
Number 445

Physiology/Institute of Biomedicine and Department of Dentistry, Institute of Clinical Medicine,
School of Medicine, Faculty of Health Sciences, University of Eastern Finland
Kuopio
2017

Grano Oy
Jyväskylä, 2017

Distributor:
University of Eastern Finland
Kuopio Campus Library
P.O.Box 1627
FI-70211 Kuopio, Finland
http://www.uef.fi/kirjasto

ISBN (print): 978-952-61-2669-2
ISBN (pdf): 978-952-61-2670-8
ISSN (print): 1798-5706
ISSN (pdf): 1798-5714
ISSN-L: 1798-5706

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Prevalence and determinants of pain and temporomandibular disorders in 6-8 year-old children
University of Eastern Finland, Faculty of Health Sciences
Publications of the University of Eastern Finland. Dissertations in Health Sciences 445. 2017. 72 p.

ISBN (print): 978-952-61-2669-2
ISBN (pdf): 978-952-61-2670-8
ISSN (print): 1798-5706
ISSN (pdf): 1798-5714
ISSN-L: 1798-5706

ABSTRACT

Pain is the most common cause for medical examination and treatment. Under normal conditions, pain is a warning sign of discomfort or injury in the body. However, when pain becomes chronic it loses its physiological significance and becomes a disease in itself. Regardless of age, the sensation of pain is always unique. According to different studies, the prevalence of pain in children ranges from 10 to 83%. Single pains, such as headache and lower limb pain, are common in childhood, but also pains occurring at the same time in more than one place in the body may be present. After toothache, pain related to temporomandibular disorders (TMD) is the second most common single pain in the head area. Pain and TMD in childhood can interfere with a child´s daily activities and on the other hand, these conditions often persist into older age. Identifying the underlying risk factors for pain complaints in childhood is crucial in order to prevent them from becoming chronic later on in adolescence or adulthood.

The present study was based on the baseline data of 512 children 6-8 years of age in the Physical Activity and Nutrition in Children (PANIC) Study. The aims were to investigate bodily pains as well as TMD pains and signs and to identify their determinants. Bodily pain complaints, lifestyle-related factors such as sedentary behavior, physical activity, quality of sleep and eating regularity, but also socioeconomic background and psychological wellbeing, were assessed by questionnaires. Temporomandibular disorders were evaluated in a dental clinical examination. Cardiorespiratory fitness was assessed by a maximal exercise stress test, body fat percentage and lean body mass with dual-energy X-ray absorptiometry (DXA), and sleep duration by the Actiheart monitor.

The present study showed that bodily pain complaints as well as signs of temporomandibular disorders were common in children 6-8 years of age. Pain was most prevalent in the lower limbs (36%) and head (31%). Low cardiorespiratory fitness and high levels of sedentary behavior were associated with increased likelihood of various pain conditions. Restless sleep, skipping meals and sleep bruxism increased the risk of morning headache. Moreover, back pain, headache and palpation tenderness in neck-shoulder muscles were related to a higher risk of TMD findings. The results of the present study are useful in identifying children at increased risk for bodily pain complaints. Modification of lifestyle habits could be significant in the prevention strategies of pain. Furthermore, the routine dental examinations in childhood should include the evaluation of TMD.

National Library of Medicine Classification: WB 176, WE 700, WL 342, WS 141, WS 440, WU 140
Medical Subject Headings: Child; Facial Pain; Headache; Musculoskeletal Pain; Pain; Pain Measurement; Risk Factors; Sedentary Lifestyle; Sleep; Surveys and Questionnaires; Temporomandibular Disorders

Vierola, Anu
Kipujen ja purentaelimistön toimintahäiriöiden esiintyvyys sekä niiden taustalla esiintyvät riskitekijät 6-8 vuotiailla lapsilla
Itä-Suomen yliopisto, terveystieteiden tiedekunta
Publications of the University of Eastern Finland. Dissertations in Health Sciences 445. 2017. 72 s.
ISBN (print): 978-952-61-2669-2
ISBN (pdf): 978-952-61-2670-8
ISSN (print): 1798-5706
ISSN (pdf): 1798-5714
ISSN-L: 1798-5706

TIIVISTELMÄ

Kipu on yleisin lääketieteellisiin tutkimuksiin ja hoitoon hakeutumisen syy. Kipu toimii varoitusmerkkinä elimistöön kohdistuvasta vammasta ja kiputuntemus on aina yksilöllinen. Myös lapsen kokema kipu ja kivun ilmaisu on yksilöllistä. Kroonistuessaan kipu ei enää toimi fysiologisena varoitusmerkkinä tai suojana vaan muuttuu sairaudeksi.

Lapsilla kipujen esiintyvyys vaihtelee eri tutkimusten mukaan 10 ja 83 %:n välillä. Yksittäiset, yhdessä kohtaa kehoa esiintyvät kivut, kuten päänsärky tai alaraajakipu, ovat yleisiä lapsilla, mutta jo lapsuudessakin kipuja voi esiintyä samaan aikaan useammassa kehon osassa. Hammassäryn jälkeen, päänsärky sekä purentaelimistön toimintahäiriöstä (TMD) johtuvat kivut ovat yleisimpiä yksittäisiä kiputiloja pään alueella. Lapsuuden aikana kehossa esiintyvät kivut voivat häiritä jokapäiväistä toimintaa ja on mahdollista, että kivut jatkuvat aikuisikään saakka. Jotta kipujen kroonistuminen saataisiin estettyä, niiden taustalla olevien riskitekijöiden tunnistaminen ja mahdollinen ennaltaehkäisy on tärkeää.

Tämä tutkimus perustuu Lasten liikunta ja ravitsemus -tutkimuksen (Physical Activity and Nutrition in Children (PANIC) Study) 512:n 6–8-vuotiaan lapsen lähtöaineistoon. Tutkimuksen tarkoitus oli selvittää alakouluikäisillä lapsilla esiintyviä kipuja ja purentaelimistön toimintahäiriöitä sekä selvittää elintapatekijöiden, sosioekonomisen taustan ja psykologisen hyvinvoinnin yhteyttä kipujen ja purentaelimistön toimintahäiriöiden esiintyvyyteen. Eri kehon osissa esiintyvät kivut sekä elämäntavat, kuten liikkumattomuus ja liikunta, unenlaatu ja ruokailukerrat sekä sosioekonominen tausta ja psykologinen hyvinvointi perustuivat kyselykaavakkeilla kerättyihin tietoihin. Unen määrää mitattiin Actiheart-mittarilla. Muut kliiniset ja antropometriset mittaukset suoritettiin tutkimushoitajan tai lääkärin toimesta. Purentaelimistön toimintahäiriöt määritettiin hammaslääkärin tekemässä kliinisessä tutkimuksessa.

Tutkimustulokset osoittivat, että elimistössä esiintyvät kivut sekä purentaelimistön toimintahäiriöt olivat yleisiä 6–8-vuotiailla lapsilla. Eniten esiintyi alaraajakipuja (36 %) ja päänsärkyä (31 %). Huono unen laatu, pääaterioiden väliin jättäminen sekä unenaikainen hampaiden narskuttelu olivat yhteydessä useammin esiintyviin aamupäänsärkyihin. Merkittävä elämäntapatekijöihin liittyvä johtopäätös oli, että huono kardiorespiratorinen

kunto ja liikkumattomuus liittyivät suurempaan kipujen esiintyvyyteen. Tutkimus osoitti myös, että lapsilla, joilla oli selkäkipua, päänsärkyä ja niskahartiaseudun palpaatioarkuutta oli lisääntynyt riski purentaelimistön toimintahäiriölöydöksille.
Tutkimustuloksia voidaan hyödyntää kun halutaan tunnistaa lapset, joilla on lisääntynyt riski kehossa esiintyville kivuille joiden syihin olisi pyrittävä puuttumaan mahdollisimman varhaisessa vaiheessa. Tutkimustulosten perusteella on suositeltavaa jo lapsilla sisällyttää hammaslääkärin tekemään tarkastukseen TMD-tutkimus.

Yleinen Suomalainen asiasanasto: elintavat; elämäntapa; kipu; krooninen kipu; lapset; purentaelimistö; päänsärky; riskitekijät; uni

Acknowledgements

The present study was carried out at the Institutes of Biomedicine and Dentistry, University of Eastern Finland, Kuopio, during the years 2007–2017 as a part of the Physical Activity and Nutrition in Children (PANIC) Study.

Firstly, I wish to express my deepest gratitude to my principle supervisor, Professor Matti Närhi. Matti – your guidance during these years with endless patience and optimism has been irreplaceable. Ten years have gone by quickly. In the future, I hope that you and Vuokko have the time to make a pit stop in Iisalmi whenever you are passing by on your way to the north.

I also want to thank my other supervisors, Professor Anna Liisa Suominen, Professor Timo Lakka and Professor Jari Kellokoski. Liisa – thank you for sharing your expertise and experience with me. You have always been there for my questions and you were the one to remind me of our main goals whenever I was getting sidetracked. Timo – it has been a privilege to work in your research group; your enthusiasm towards science is amazing. Moreover, you have created an encouraging and warm atmosphere for your PANIC team. Jari – thank you for guidance toward clinical research. Your support in the early years has meant a lot to me.

Secondly, I want to thank Professor Marja Mikkelsson and Tuija Teerijoki-Oksa, DDS, Ph.D., for reviewing this thesis. Your careful work and constructive comments helped me to improve the quality of my thesis significantly. I am honored that Professor Eija Kalso agreed to act as opponent during the public examination.

I want to thank my co-authors Virpi Lindi, Anna Viitasalo, Niina Lintu, Aino-Maija Eloranta, Juuso Väistö, Hanna-Maaria Lakka and Tiina Ikävalko for their contribution to this work. All of you, but also the whole PANIC Study team, showed me what it is to work in a research group. Whenever I needed help or advice there was always someone to ask and to give a helping hand. I warmly thank Merja Atalay, who has helped me a lot to resolve practical issues during these years, and Riitta Myllykangas for her valuable work with statistical issues. I express my warm gratitude to Professor Hannu Kokki for his contribution to this work.

From our research group, Tiina deserves a special thank you. Our conversations during these years, knowing that your door was always open for me, have helped me a lot.

In addition, I owe my thanks to Anna Vuolteenaho, MA, for her skillful revision of the language of my thesis.

I thank all the children and families participating in the PANIC Study for their time and patience. Thank you, Kuopio Social and Health Center, for providing the facilities during the dental examinations.

I want to thank my dear friends warmly for the support you have given during these years. Sari, thank you for dragging me to the gym and running. You´ve always been there for me and your friendship means a lot to me. Jossu, our friendship has lasted for years despite the distance. Long phone calls with you have made my life so much lighter.

I want to thank my whole family and relatives for supporting and helping me in so many ways over these years. Thank you mom and Pentti. Thank you Mirjami and Hannu. I owe my special thanks to my children, my precious ones, Maiju, Jaakko, Malla and Tatu, for all the love and laughter you are bringing to my life. You remind me every day of what is really important in life. *Sweet Child O´Mine.*
Finally, I want to thank my husband Ville for all the love and support. Your endless patience and encouragement has made me complete this work. *You´re my sharp dressed man.*

In appreciation of their financial support for this work, I thank the Institute of Biomedicine, University of Eastern Finland, the Finnish Dental Society Apollonia, the Northern Savo Dental Society, FINDOS (Finnish Doctoral Program in Oral Sciences) and the Finnish Women Dentists´ Association.

Kuopio, December 2017

Anu Vierola

- Children see magic because they look for it-

Christopher Moore

List of the original publications

This dissertation is based on the following original publications:

I Vierola A, Suominen AL, Ikävalko T, Lintu N, Lindi V, Lakka H-M, Kellokoski J, Närhi M, Lakka TA. Clinical signs of temporomandibular disorders and various pain conditions among children 6 to 8 years of age: The PANIC Study. *J Orofac Pain 26:17-25, 2012.*

II Vierola A, Suominen AL, Lindi V, Viitasalo A, Ikävalko T, Lintu N, Väistö J, Kellokoski J, Närhi M, Lakka TA. Associations of sedentary behavior, physical activity, cardiorespiratory fitness and body fat content with pain conditions in children: the Physical activity and nutrition in children study. *J of Pain 17:845-853, 2016.*

III Vierola A, Suominen AL, Eloranta A-M, Lintu N, Ikävalko T, Närhi M, Lakka TA. Determinants for craniofacial pains in children 6-8 years of age: the PANIC study. *Acta Odontol Scand 75:453–460, 2017.*

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Contents

Abbreviations

BMI	body mass index
BMI-SDS	body mass index - standard deviation score
CI	confidence intervals
COMT	catechol-Omethyl-transferase
CRF	cardiorespiratory fitness
DXA	dual-energy X-ray absorptiometry
ECG	electrocardiogram
FPS	faces pain scale
FPS-R	faces pain scale - revised
GCT	gate control theory
IASP	international association for the study of pain
LM	lean body mass
MPQ	McGill pain questionnaire
n	number
NRS	numeric rating scales
OR	odds ratio
PANIC	Physical Activity and Nutrition In Children
RCD/TMD	research diagnostic criteria for temporomandibular disorders
DC/TMD	diagnostic criteria for temporomandibular disorders
SES	socioeconomic status
SDB	sleep-disordered breathing
TMD	temporomandibular disorders
W	watts
WSP	widespread pain

1 Introduction

Pain is a normal physiological sensation and one of the body's most important communication tools by telling that something is wrong and needs attention. According to the definition by the International Association for the Study of Pain (IASP), pain is highly subjective, depending on individual thresholds and experiences. Pain sensation becomes disabling when it becomes chronic and is associated with suffering. It is associated with many different ailments and injuries, and may widely vary in severity, duration, site and etiology.

TMD (temporomandibular disorder) is a term referring to musculoskeletal disorders affecting the masticatory muscles and/or the temporomandibular joints (Okeson 2014). Moreover, jaw and facial pain can be symptoms of temporomandibular disorders (TMD).

Children frequently experience pain (Perquin et al. 2000a, Roth-Isigkeit et al. 2003), but pain among children is still one of the most ignored and under-treated conditions (Palermo 2009). Unrelieved pain in children interferes not only with children´s school attendance, quality of life and psychological functioning, but also with day-to-day life in the family (Palermo 2000, Walker 2008, Kernick and Campbell 2009). In addition, pain among children and adolescents not only affects physical and psychosocial aspects of daily family life but may also predispose them to experience recurrent pain-related illnesses in adulthood (Walker and Greene 1989, Walker et al. 1995, Brattberg 2004).

There are many predisposing factors for pain complaints. Overweight and obesity have been observed to be associated with musculoskeletal pains in children and adolescents (Tanamas et al., 2012). Sedentary behaviors, such as using a computer (Torsheim et al. 2010), have also been observed to be associated with musculoskeletal pains in adolescents. However, there are no studies on the associations of various types of sedentary behavior with pain conditions in children, although such behaviors may be differentially related to pain. The associations of physical activity with pain conditions in children and adolescents have been inconsistent, showing physical activity to be variably associated with either an increased or decreased risk for having pain (Jones et al. 2003, Wedderkopp et al. 2009, Sollerhed et al. 2013). However, there are no studies on the association between cardiorespiratory fitness and pain in primary-school children.

On the other hand, there is evidence that the recurring and increasing incidence of pain among children generates significant costs for the community, making the implementation of reforms and preventive care programs necessary (Kamper et al. 2016). Therefore, studying pain determinants already in childhood is important for understanding the origin of common and disabling pain-related illnesses in adulthood. The objective of the present study was to investigate the prevalence and determinants of pain complaints and temporomandibular disorders in a population sample of children 6-8 years of age.

2 Review of the literature

This review of literature provides an overview of the recent literature on pain conditions and temporomandibular disorders and their determinants.

2.1 DEFINITION OF PAIN

According to IASP, pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage. Pain can be classified depending on its location (e.g. headache, abdominal pain), or as acute or chronic pain. Further, pain can be classified as nociceptic, neuropathic or idiopathic.

2.2 PATHOGENESIS AND COMMON THEORIES OF PAIN

The pathogenesis of pain sensation includes mechanisms that play a role in acute or chronic pain. As described above, pain itself is an unpleasant sensory and emotional experience induced in response to a peripheral stimulus that undergoes a physiological process ultimately resulting in the sensation of pain.

Many pain theories have been suggested, and pain research has traditionally focused on the sensory modalities and the neurological transmissions identified solely on a biological level. More recent theories have been developed. The Gate Control Theory (GCT, Melzack and Wall, 1965) is one that has been well accepted. GCT describes the central process of pain using a biodimensional model, which includes psychological and physiological aspects (Melzack and Wall 1965). The GCT has been the basis for creating a biopsychosocial model by adding the genetic and immunological perspectives and psychosocial aspects related to pain (Engel 1980). In the biopsychosocial model, pain is viewed as dynamic interaction among and within the biological, psychological, and social factors unique to each individual (Figure 1). Its biological aspect includes sex, pubertal development, physical health and genetic factors. The psychological aspect can involve individual beliefs, anxiety and depression. Moreover, the social aspects include child-parent relationship, socioeconomic status, and culture and school environment. Understanding this theoretical foundation allows recognizing the risk factors for pain in children and, accordingly, better pain diagnoses and management.

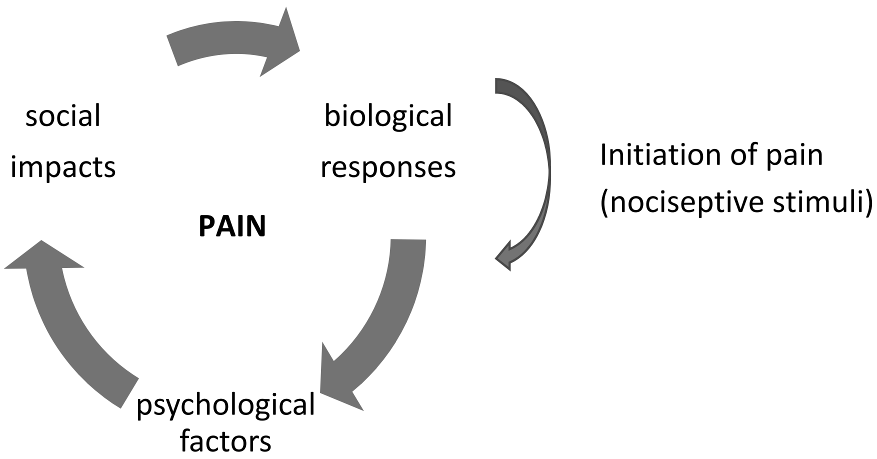

Figure 1. Biopsychosocial model of pain.

2.3 ASSESSMENT OF PAIN

Pain is a difficult medical condition to assess because only the person with the pain can actually feel it. Also, each person experiences pain differently. There is no single common or easy method for measuring or assessing pain. The methods used for pain assessment are based on indirect, self-report, observational (behavioral), or physiological data. Self-report is considered primary and should be obtained if possible. The methods for pain assessment help to determine the severity, type, location and duration of the pain, and are used to make an accurate diagnosis, determine a treatment plan, and evaluate the effectiveness of treatment. Precise measurement of the pain experience can be performed only with the assistance of several tools and methods (Sharav and Benoliel 2015). In children, the goal of pain assessment is to provide accurate information about the location and intensity of pain and its effects on the child's functioning.

Pain questionnaire is a useful, simple and cheap approach to assess pain conditions. One of the most widely used questionnaires for the multidimensional assessment of pain is the McGill Pain Questionnaire (MPQ) (Melzack 1975). The MPQ assesses both the quality and intensity of subjective pain and is useful from 13 years of age on (Melzack 1975). In epidemiological studies concerning pain in children, pain questionnaires administered to the parents are used (Aromaa et al. 2000, Perquin et al. 2000, Roth-Isigkeit et al. 2005). Also pain scale measures are useful when measuring pain intensity. Visual analog scale, VAS, is one of the most frequently used pain scales, but also numeric rating scales (NRS) or verbal rating scales (VRS) are useful (Schoch et al. 2017). Numeric rating scales can be used with most children older than 8 years of age (von Baeyer). Faces pain scales (FPS) are more suitable for younger children (Tomlinson et al. 2010, Tsze et al. 2013). Pain scale measures a patient's pain intensity or other features, e.g. unpleasantness of the pain experience.

The Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) is an example of a multidimensional questionnaire designed for temporomandibular disorders (TMDs) developed by Dworkin and LeResche (1992) and revised recently by the International RDC/TMD Consortium Network of the Association for Dental Research and the Orofacial Special Interest Group of the IASP (Schiffman et al. 2014).

To assess widespread pain (WSP) among adults, White and coworkers (1999) established a widely used set of screening criteria for WSP where simultaneously occurring pain in an upper extremity, a lower extremity, and either neck, back, or chest were defined as WSP. At the moment, no diagnostic criteria for WSP in children are available.

2.4 MUSCULOSKELETAL PAINS

Musculoskeletal pain conditions are common in childhood affecting the muscles, ligaments, tendons and bones. In various studies the prevalence of such pain symptoms during the past 3 months in children varies between 22% and 83% (Perquin et al. 2000, Roth-Isigkeit et al. 2005, El-Metwally et al. 2007a). It has been shown that the prevalence of musculoskeletal pains increases with age. A follow-up study showed that the prevalence of any musculoskeletal complaints for at least 1 month increased from 15.8% at age 11 to 24.4% at age 14, and this was also found for upper extremity complaints (from 4.7% to 7.6%), back complaints (from 2.7% to 9.3%), and lower extremity complaints (from 11.9% to 14.7%) (Picavet et al. 2016). Huguet and Miro (2008) showed that over one third of children and adolescents 8-16 years of age had chronic musculoskeletal pains. According to Fares et al. (2017), among 208 children and adolescents with nonspecific neck pain, musculoskeletal pain was diagnosed in 180 (87%).

2.4.1 Back pain

Most of the regional musculoskeletal pain studies have focused on low back pain. A Finnish nationwide study showed that the prevalence of back pain was 1% among 7-year-old and 6% among 10-year-old schoolchildren, but increased with age, being 18% among both 14- and 16-year-old adolescents (Taimela et al. 1997). Another study among Danish children found that 33% of the 9-year-olds had had back pain within the past month (Kjaer et al. 2011).

2.4.2 Lower limb pain

Of single musculoskeletal pains, lower limb pain is the most common pain among children (Sillanpää and Anttila 1996, Perquin et al. 2000, Lundqvist et al. 2006). Lower limb pain is also common among adolescents. Furthermore, in a prospective study conducted on adolescents aged 12-18, the annual cumulative incidence of pain for each musculoskeletal location was estimated and the highest rates were found for lower limb pain (Ehrmann-Feldman et al. 2002). Lower limb pain can be due to many causes such as muscle cramp or injury. When studies estimate the prevalence of recurrent lower limb pain in children, they are often described as "growing pains". In studies, "growing pains" have been reported since the 19th century (Lehman and Carl 2017). There are no single diagnostic criteria for growing pains, but the inclusion criteria for diagnosis are nonarticular pains in legs that generally occur late in the day or at night (Peterson 1977, Peterson 1986). Moreover, lower limb pain is more likely the most common location for pains due to trauma (Anderson 2002, El-Metwally et al. 2007a). Children with lower limb pain have many restrictions, such as not meeting friends and inability to pursue hobbies. They also visited a doctor more often than children with headache (Roth-Isigkeit 2005).

2.5 ABDOMINAL PAIN

Abdominal pain is a common complaint in children. In a German study, the 3-month prevalence of abdominal pain among children and adolescents was 44% (Roth-Isigkeit 2005). Higher rates, with 60% in Sweden and 90% in the United States, have been reported (Östberg et al. 2006, Saps et al. 2009). El-Metwally et al. (2007b) found that over 20% of schoolchildren aged 11-14 years experience new-onset non-self-limiting abdominal pain over a 1-year period. Although there are many potential organic causes, abdominal pain in childhood is usually of functional origin. Behavioral symptoms, sleep disturbances and psychological issues are commonly linked with abdominal pain in children (Apley et al. 1958, Huang et al. 2000). Abdominal pain often coexists with other somatic pain conditions. Perquin et al. demonstrated that one quarter of children reported pain in more than one site during the past 3 months, the most common combination being headache and abdominal pain (Perquin et al. 2000).

2.6 HEADACHES

The pain being above the eyes or the ears, behind the head (occipital), or in the back of the upper neck is defined as headache. The International Headache Society (IHS) has classified headaches as primary headaches, secondary headaches, cranial neuralgias, facial pain and other headaches (Headache Classification Committee of the International Headache Society, 2013). Primary headaches are not associated with other diseases. Secondary headaches are caused by other diseases. Examples of primary headaches are migraine, tension headaches, and cluster headaches. Tension headache and migraine are the two most common types of primary headache in children (Sillanpää and Piekkala 1984, Anttila 2006). Headache can also be classified by time of day; for example, morning headache appears soon after waking up.

Headache is a common complaint among children (Sillanpää et al. 1996, Lundqvist et al. 2006). The prevalences of headaches according to eight different studies performed in five different countries are presented in Table 1. The reported prevalence varies widely in the literature, but is estimated to be 10–20% at the age 7-8 years with a progressive increase with age, up to values of about 27–32% at the age of 13–14 years (considering monthly appearance). The most frequent type of recurrent headache in young children is migraine, while the frequency of tension type headache increases with advancing age. Before puberty, migraine headaches are equally frequent in boys and girls, but after puberty more women than men have them (Carlsson 1996, Lipton et al. 2001). Similar observations have been made concerning headaches in general; until puberty, no gender differences have been seen (except for a slight male predominance), while at a later stage an increase has been noted among girls, lasting into adulthood (Perquin et al. 2000, Abu-Arafeh et al. 2010). Overall, it has been shown that headache prevalence increases with age (Bugdayci et al. 2005, Fendrich et al. 2007).

Headaches in childhood are often associated with, and deeply influenced by, many comorbid situations and can result from a number of causes, such as trauma or tumor, a metabolic or vascular disease, sinusitis and genetic predisposition. Migraine often goes undiagnosed or is misdiagnosed as tension or sinus headache. Although much remains to be discovered, the pain in migraine attacks is multifactorial (Bellini et al. 2013b). One mechanism suggests activation of the trigeminovascular system and is thought to be mediated by cortical spreading depression (Ayata 2010). Migraine headaches may also have a genetic predisposition (Montagna 2008). The causes of tension-type headache also remain poorly understood. A combination of muscular factors, abnormal pain-perception mechanisms, and central emotional abnormalities exists, all possibly linked to dysfunction of the brain-stem serotonergic interneurons (Bellini et al. 2013b). Furthermore, central and peripheral sensitization is involved.

Headache can lead to psychological impairment and decreased quality of life, especially for children who experience chronic migraine (Abu-Arefeh and Russell 1994, Perquin et al. 2000a). However, the restrictions in daily activities because of headache have been poorly investigated. Moreover, little is known about the relationship between headache conditions in children and e.g. cardiorespiratory fitness or lifestyle-related factors, such as various types of sedentary behaviors, although they may be differentially related to headache.

Table1. The reported prevalences of children and adolescents with headaches according to age and other findings of the study.

Author(s) **Location**	**n**	**Age (yrs)**	**Prevalence %**	**Other findings**
Sillanpää and Anttila, 1996 Finland	1436	7	Year 1974: 14% headache 2% migraine Year 1992: 52% headache 6% migraine	No statistically significant reasons for increases were found.
Carlsson, 1996 Sweden	1297	7-16	26% ≥1 /month; 6% several times a week or daily (frequent)	Grades 1-3; had increased risk of frequent headache. Grades 4-6; reported more frequent headache in districts with high unemployment. Grades 7-9; girls had significantly more headache than boys.
Bugdayci et al. 2005 Turkey	5562	7-10	49% recurrent	Prevalence increased with increasing age. More prevalent in girls, those with lower socioeconomic status, and family history of headache.
Fendrich et al. 2007 Germany	3072	12-15	69% ≥1 /3 months; 4% ≥14 /3months; 1% ≥15 /3months	Prevalence increased with increasing age. More prevalent in girls than boys.
Kröner-Herwig et al. 2007 Germany	5588	7-14	53% ≥1 /6 months 7% ≥1 /month	6-month prevalence increased with increasing age (from 39% at age of 7 to 63% at 14 years).
Rho et al. 2012 South Korea	5039	6-18	29% recurrent	Migraine 9% (girls 10%, boys 7%) Tension type headache 14% (girls 16%, boys 11%) Others 7%.
Gassmann et al. 2012 Germany	2952	7-14	27% <1 /month 7% ≥1 /week	Recurrent headache more prevalent in girls than boys.
Carasco and Kröner-Herwig, 2016 Germany	5474	9-15	20% ≥1 /week	More prevalent in girls (24%) than boys (16%). Migraine 4% Tension type headache 8% Non-categorizable headache 8%

2.7 OROFACIAL AND CRANIOFACIAL PAIN

Orofacial pain is a general term that covers any pain felt in the mouth, jaws and face. Orofacial pains are common and have various causes. The diagnostic criteria for orofacial pains can be found both in the International Association for the Study of Pain (IASP) classification (Merskey and Bogduk 1994) and in the classification of IHS (Headache Classification Committee of the International Headache Society, 2013). There are some differences between these two classifications. It is estimated that more than 95% of cases of orofacial pain result from dental origin, and in most of cases the pain is acute. The reminder is considered chronic orofacial pain. The second most common cause of orofacial pain is TMD (Manfredini et al. 2011), the prevalence figures ranging from 4% to 12% in adult population (Le Resche 1997).

Craniofacial pain is an overlapping topic which includes pain perceived in the head, face, and related structures, sometimes also including neck pain (Armijo et al. 2006). Craniofacial pains are frequent conditions among children, headache being the most common of them (Perquin et al. 2000a, Karibe et al. 2015).

2.8. TEMPOROMANDIBULAR DISORDERS (TMD)

TMD is a collective term that embraces a number of clinical problems that involve the temporomandibular joint, the masticatory muscles, and the associated structures (Toscano and Defabiani 2009). Symptoms of TMD, such as jaw and facial pain, as well as signs of TMD, such as joint sounds, impaired movement of the mandible, and limited mouth opening, are common, but usually mild, also among children (Sönmez et al. 2001, Thilander et al. 2002, Toscano and Defabiani 2009) (Figure 2).

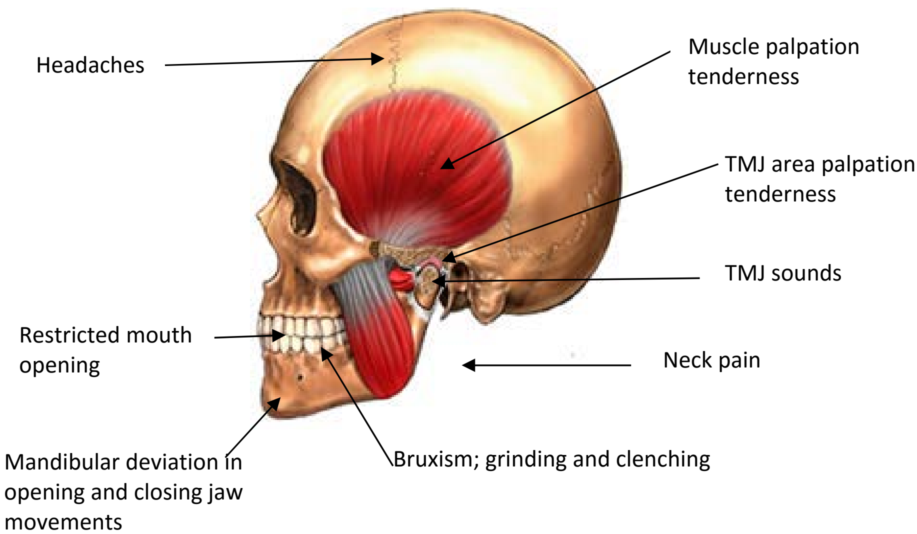

Figure 2. TMD signs and symptoms.

The reported prevalence of TMD in children and adolescents varies widely (Alamoudi et al. 1998, List et al. 1999, Karibe et al. 2015) (Table 3). This variation may be due to differences in populations studied, diagnostic criteria, examination methods and timing, and inter- and/or intra-rate variations of examining practitioners (Nydell et al. 1994, Manfredini et al. 2011). Moreover, in studies on children prevalences are mostly based on questionnaires completed by parents while those based on clinical examinations are rare. One reason for the wide variation in the reported prevalence may be that the signs and symptoms of TMD are usually mild or moderate or fluctuating (Egermark et al. 2001). The prevalence increases with age in children and adolescents. It has been reported that the TMD-related symptoms were rare in three- and five-year-olds whereas five to nine percent of 10- and 15-year olds reported more severe symptoms (Köhler et al. 2009). Bonjardim et al. (2003) reported that 34% of the children with primary dentition had signs and/or symptoms of TMD. According to an epidemiological study including 4,724 children and adolescents aged five to 17 years, 25% of the subjects had symptoms of TMD. Clicking, as a sign of TMD, was found in 3% of children with primary dentition, 10% in those with late mixed dentition, and 17% in adolescents with permanent dentition (Thilander et al. 2002). Although TMD pain in children increases with age among both girls and boys, recent reports have indicated a significantly higher prevalence of symptoms and greater need for treatment in girls than boys (LeResche et al. 2005, LeResche et al. 2007). Even though TMD and headache have closely related pathologies, many studies among children have focused on headache rather than TMD.

Table 2 shows the main findings of thirteen studies with great variation in the prevalences of the signs and symptoms of TMD in children and adolescents.

Table 2. The reported proportions of children and adolescents of different age with signs and symptoms of TMD.

Author(s) **Location**	**n**	**Age (yrs)**	**Signs of TMD**	**Symptoms of TMD**
Alamoudi et al. 1998 Saudi Arabia	502	3-7	8% joint sounds 7% muscle palpation tenderness 3% deviation during movement 2% restricted mouth opening.	3% pain during joint movement
List et al. 1999 Germany	862	12-18	7% were diagnosed with TMD pain (RDC/TMD)	Of those with TMD pain had pain: in the head: 21% in the temples: 12% in the face, temporomandibular joint, or jaws: 3%
Sari and Sonmez 2002 Turkey	394	9-14	58% TMD signs	68% TMD symptoms
Vanderas and Papagiannoulis 2002 Greece	314	6-8	Posterior crossbite associated with TMJ tenderness, overjet and effect on TMJ clicking. Clenching and biting of objects associated with temporomandibular muscle tenderness.	Pain on wide opening was affected significantly by lip/cheek biting
Farsi 2003 Saudi Arabia	1940	3-15	21% TMD signs 12% joint sounds 5% restricted mouth opening	14% headache 11% pain on chewing
Bonjardim et al. 2005 Brazil	217	12-18	27% joint sounds	22% headache 13% facial/jaw pain
Nilsson et al. 2005 Sweden	28899	12-19	-	4% TMD pain
Feteih 2006 Saudi Arabia	385	12-16	21% had at least one sign of TMD 14% joint sounds 5% restricted opening 4% opening deviation	33% had TMD symptoms 22% headache 14% pain during chewing 9% hearing TMJ noises
LeResche et al. 2007 USA	1996	11	29% facial pain 7% met RDC/TMD Criteria	-
Moyaho-Bernal et al. 2010 Mexico	235	8-12	39% joint sounds 19% joint pain 48% muscular pain	-
Branco et al. 2013 Brazil	93	6-14	36% mild TMD 26% moderate TMD 11% severe TMD	Headache associated with moderate and severe TMD
Karibe et al. 2015 Japan	1415	11-15	-	13% TMD symptoms
Al-Khotani et al. 2016b Saudi Arabia	456	10-18	27 % were diagnosed with at least one TMD sign or symptom (RDC/TMD)	

2.9 MULTIPLE PAIN AND WIDESPREAD PAIN (WSP)

Pain existing in at least two different areas of the body is defined as multiple pain (Perquin et al. 2000a). Widespread pain is characterized by pain on both sides of the body, above and below the waist. Widespread pain is the primary symptom of fibromyalgia. The 1990 American College of Rheumatology guidelines for making a diagnosis of fibromyalgia are currently the most widely used criteria (Wolfe et al. 1990). WSP is fairly common among adults with a prevalence of around 13% (Croft et al. 1993). Jones et al. (2003) found in their population-based prospective study that WSP was as common in children aged from 11 to 14 years as among adults. The results of a prospective study among schoolchildren 10-12 years of age also showed that WSP is as common in schoolchildren as in adults, but unlike in adults, childhood WSP tends to have fluctuating course with a more favorable prognosis (Mikkelsson et al. 2008).

Table 3 presents the reported prevalences of multiple pain and WSP in children and adolescents according to eight different studies performed in five different countries. Two of the studies are German and two are Finnish.

Table 3. The reported prevalences of children and adolescents with multiple and widespread pain (WSP) according to age and other findings of the study.

Author(s) **Location**	**n**	**Age (yrs)**	**Prevalence and site**	**Other findings**
MULTIPLE PAIN				
Kristjansdottir 1997 Iceland	2098	11-12, 15-16	Pain combinations (head, abdomen, back) 16% weekly 78% monthly	Girls reported more pain than boys.
Bakoula et al. 2006 Greece	7925	7	Recurrent pain (two or more sites) 7%	Girls experienced more recurrent pain than boys. Children who spent more time watching TV were more likely to experience pain.
Ostkirchen et al. 2006 Germany	555	5-7	Pain combination (head, abdomen) 49%	Boys experienced more headaches than girls.
Petersen et al. 2006 Sweden	1155	6-13	Pain combination (head, abdomen, back) 24% weekly 32% monthly	Prevalence increased with increasing age.
Kröner-Herwig et al. 2011 Germany	2219	7-14	Recurrent pain (two or more sites) 54%	Girls experienced more pains than boys.
WIDESPREAD PAIN (WSP)				
Mikkelsson et al. 1997 Finland	1756	10-12	8%	Persisted in 30% at 1-year follow-up.
Jones et al. 2003 England	1440	11-14	15%	New WSP onset 8% at 1-year follow-up.
Mikkelsson et al. 2008 Finland	1756	10-12	8% at baseline 9% at 1-year follow-up 15% at 4-year follow-up	Prospective 4-year follow-up study.

2.10 DETERMINANTS OF PAIN AND TEMPOROMANDIBULAR DISORDERS (TMD)

Significant correlations have been reported between childhood pain and a number of its potential determinants. These include demographic, anthropometric, various life-style related and psychological factors. These determinants can be separate or associate with each other.

The same potential determinants have been reported to correlate with TMD, although many studies show a poor correlation between any single predisposing factor and resulting signs (i.e., findings identified by the dentist during the clinical examination) and symptoms (i.e., those reported by the child or parent) of TMD. Alterations in any single tooth or a combination of teeth, periodontal ligament, TMJ or the masticatory muscle-related morphological and/or functional abnormality may lead to TMD (Hiatt and Gartner 1987).

2.10.1 Demographics

Demographic factors such as age, sex and race/ethnicity are well recognized as relevant to pain and TMD sensitivity, and clinical pain and TMD expression.

It has been found that the prevalence of musculoskeletal pains among children increases with age and is particularly high among adolescents. It has also been found that the prevalence of chronic pain in children and adolescents (0-18 years of age) increases with age, peaking in the 12-15-years age group (Perquin et al. 2000a). Whether girls in early childhood are more likely to report pain than boys is unclear, but among school-aged children and adolescents girls are more likely to do so. Among children and adolescents 7-12 years of age, girls reported significantly more days with headaches than boys (Lundqvist et al. 2006). Moreover, female gender and younger age were positively related to experiencing abdominal pain among adolescents (van der Week et al. 2010). However, no gender difference was found in the prevalence of low back pain among schoolchildren 7-16 years of age (Taimela et al. 1997). In contrast, boys had a significantly higher prevalence rate for lower limb pain than girls in a large sample of children and adolescents aged 3-17 years (Yong et al. 2011).

In adults, the relationships between gender and age and pain complaints are clear. Women are more likely to report pain complaints (Croft et al. 1993). Regarding multiple pain and widespread pain, a higher number of pain sites are found in women (LeResche 2000, Carnes et al. 2007). As for TMD, randomized controlled trials indicate that estrogen does not play a role in the etiology of TMD, whereas cohort and case controlled studies show the opposite (deLeeuw and Klasser 2013a). Findings from several studies have showed that female gender is associated with TMD (Dworkin et al. 1990, LeResche et al. 1997, Kuttila et al. 1998, List et al. 1999, Rutkiewich et al. 2006, Slade et al. 2011, Kim et al. 2015, Visscher et al. 2015).

Ostrom et al. (2017) reported that women were significantly more pain sensitive than men, and that there were racial differences, e.g. non-Hispanic white individuals were less pain-sensitive than other races. The study also suggested that racial differences were related to differences in central nociceptive processing, including modulation imposed by cognitive, psychological, and/or affective factors. In children and adolescents 4-12 years of age, girls were more likely than boys and African American children were more likely than white children to report TMD symptoms (Inglehart et al. 2016).

2.10.2 Anthropometrics

The growth in height is usually considered to be associated with "growing pains", which is a common, benign syndrome of recurrent discomfort that occurs in young children. However, the peak incidence does not correspond with the time of the most rapid growth, and the etiology of the condition thus remains unclear (Lehman and Carl 2017). In fact, the possible relationship between the growth in height and various pain conditions has been sparsely studied.

The WHO defines overweight and obesity as abnormal or excessive fat accumulation that may impair health (World Health Organization. Obesity and Overweight Fact Sheet No. 311 2011 http://www.who.int/mediacentre/factsheets/fs311/en/). Body mass index (BMI) is a simple measure of weight-for-height relation that is commonly used to classify overweight and obesity in adults. It is defined as a person's weight in kilograms divided by the square of his height in meters (kg/m2). Overweight and obesity in children are a significant public health problem. They have been observed to be associated with pediatric musculoskeletal pains (Paulis et al. 2014). Moreover, they have the potential to have an impact on a child's osteoarticular health, resulting in ongoing chronic pain (Bell et al. 2007, Deere et al. 2012). Recently, a significant increase in pain was found in the lower extremities of extremely obese children compared to those with normal weight across three age ranges between 2 and 19 years (MacFarlane et al. 2011).

2.10.3 Lifestyle-related factors

Sedentary behavior

Sedentary behavior represents postures or activities that require very little movement. Examples include prolonged sitting, watching television, playing passive video or computer games, extended time spent on the computer (surfing the internet or working), and motorized transportation. Using a computer and watching TV have been associated with neck, shoulder and low back pain and headache among children and adolescents (Hakala et al. 2006, Torsheim et al. 2010), and sitting has been linked to musculoskeletal pain at multiple sites (Jones et al. 2003) among adolescents. However, there are no studies on the associations of various types of sedentary behavior, such as sedentary behavior related to academic tasks, with pain conditions in children 6-8 years of age, although different sedentary behaviors may be differentially related to pain.

Physical activity

Physical activity is defined as any bodily movement produced by skeletal muscles that requires energy expenditure (Caspersen et al. 1985). Physical activity in daily life can be categorized into occupational, sports, conditioning, household, or other activities. The physical activity recommendations suggest that school-aged children and adolescents should accumulate at least 60 minutes moderate-to-vigorous physical activity daily (Strong et al. 2005).

Physical activity can be assessed using both subjective and objective methods. In young children, questionnaires administered to parents or teachers are used, because young children can rarely report their activity accurately (Ekelund et al. 2011). Even though estimating children´s physical activity is difficult for adults, questionnaires are useful to assess long-term physical activity and a wider range of activity, such as ball games (Ekelund et al. 2011). Of objective methods, accelometers and actigraphy have become the most used methods to assess habitual physical activity in children. Moreover, actigraphy can be used to assess how subjective and objective measures of physical activity are related to pain complaints (Walker and Greene 1991, Kashikar-Zuck et al. 2010). Impairments in physical activity are common in children and adolescents with pain complaints. It has been shown that among subjects 6-20 years of age with musculoskeletal pain, maximal exercise capacity was significantly decreased compared with age- and gender-matched control subjects (Engelbert et al. 2006). Moreover, Wilson and Palermo (2012) showed that adolescents with chronic pain have lower physical activity levels compared to healthy ones.

Cardiorespiratory fitness (CRF) and neuromuscular performance

The capacity of the cardiopulmonary and vascular systems to deliver oxygen to the exercising skeletal muscles and the oxidative mechanisms of those muscles to utilize oxygen in energy generation is defined as cardiorespiratory fitness (CRF) (Whaley et al. 2006). There are no studies on the association between CRF and pain in children.

Neuromuscular performance can be broadly defined as an ability to carry out the activities of daily living in a controlled manner and without excessive fatigue (Garber et al. 2011). Neuromuscular performance can be divided into muscular endurance, muscular strength and motor performance (Caspersen et al. 1985, Garber et al. 2011). A recent meta-analysis showed that high back muscle endurance, but not high back muscle strength or aerobic capacity, protected from back pain in children and adolescents (Lardon et al. 2015). Strength training significantly decreased tension type headache frequency among girls 9-18 years of age (Tornøe et al. 2016).

Sleep

Sleep is defined as a physiological and behavioral state characterized by partial isolation from the environment. Sleep affects our daily functioning and our physical and mental health in many ways. A concerning and common association with pediatric pain is poor sleep, which may be characterized by difficulty falling or staying asleep, poor subjective sleep quality, short sleep duration, or disrupted sleep architecture. Poor sleep is associated with compromised emotional, cognitive, and behavioral functioning in healthy children (O`Brien and Gozal 2004, Taras and Potts-Datema 2005, Owens 2009) and has been related to reduced physical, social, and emotional function in adolescents with pain (Palermo and Kiska 2005) in addition to and beyond the effects of the pain itself. Evidence indicates that good quality sleep promotes immune system function, while systemic inflammation due to immune system dysfunction has been related to increased pain (Motivala and Irwin 2007).

The existence of an intimate relationship between sleep and headache has been recognized for over a century, although the nature of this association is still enigmatic. It is known that sleep deprivation, or, on the contrary, prolonged sleep, can promote the onset of headache, in particular migraine attacks (Bellini et al. 2013a). On the other hand, in many cases, and especially in children, sleep, either spontaneous or induced by hypnotics, constitutes the decisive factor for resolution of migraine attacks (Stovner et al. 2003). Results from a recent systematic review indicate that sleep problems such as quality or quantity of sleep or daytime tiredness are not risk factors for general musculoskeletal pain onset in children and adolescents 6-19 years of age (Andreucci et al. 2017). Furthermore, strong evidence was found that sleep problems are not a risk factor for the onset of WSP (Jones et al. 2003, Mikkelsson et al. 2008). Of single pains, strong evidence for an association between neck pain and low sleep quality and/or daytime tiredness among girls was found (Ståhl et al. 2008). Moreover, sleep-disordered breathing (SDB), which represents a continuum of symptoms from simple snoring to obstructive sleep apnea syndrome, being one of the most common sleep disturbances, has been associated with headache in children (Bruni et al. 1997, Wei et al. 2007, Carra et al. 2012).

Parafunctional habits such as bruxism, clenching and hyperextension (e.g. wide yawn) are thought to contribute to the development of TMD by joint overloading or by muscle hyperactivity (Dym and Israel 2012). Bruxism may occur while the patient is asleep or awake; sleep bruxism is a different entity from daytime bruxism. The results of a study performed on 854 patients younger than 17 years indicated the prevalence of bruxism to be 38% with no difference between sleep or daytime bruxism (Cheifetz et al. 2005). In another study, a parafunction in childhood was found to be a predictor of the same parafunction 20 years later (Carlsson et al. 2002). The literature on the association between parafunctions and TMD in pediatric patients is contradictory (Winocur et al. 2001, Castelo et al. 2005, Barbosa et al. 2008). Children who grind their teeth were found to complain more often of pain and muscle tenderness when eating (Alamoudi et al. 2001).

Diet

There is evidence that eating habits appear to be associated with pain complaints among children (Bonilla et al. 2011, Crowell et al. 2015). Eating habits – what you eat, when you eat and how you eat – can work as a trigger factor for abdominal pain. Moreover, skipping meals can be a possible trigger of headaches. Eating regularly throughout the day can be very helpful for migraine sufferers who are sensitive to long time periods without food (Moschiano et al. 2012). Children and adolescents with chronic pain frequently report disturbances in sleep and eating habits, reduced participation in social activities or hobbies, and school absence, which affects their overall sense of well-being (Roth-Isigkeit et al. 2005).

2.10.4 Psychosocial and psychological factors

It has been shown that psychosocial factors, such as depression, anxiety and low self-esteem, are related to pain complaints among children.

In a study among children 9-13 years of age, pain associated with poor self–rated health, psychological symptoms, and unhappiness with school experiences (van Dijk et al. 2008). Brun Sunblad et al. (2007) found that feeling sad was associated with pain in girls while no psychological variable was associated with musculoskeletal pain in boys.

Psychological symptoms such as depression, anxiety, and low self-esteem associated with increased headache prevalence (Rhee 2000, Stanford et al. 2008). It has been shown that among subjects 9-13 years of age, pain associates with poor self-rated health, psychological symptoms, and unhappiness with school experiences (van Dijk et al. 2008). Moreover, in studies focusing on abdominal pain, anxiety in children and their mothers (Ramchandani et al. 2005), anxiety and depression in children (Stanford et al. 2008), feelings of sadness in younger girls (Brun Sunblad et al. 2007), and school stress (Oh et al. 2004) were associated with abdominal pain. One study examined the relation between psychosocial factors and multiple pain and found that complaints of recurrent chronic pain were significantly correlated with several variables: chronic health problems, frequent change of residence, poor performance at school, frequent television watching, and rare interactions with other children (Bakoula et al. 2006). Moreover, psychosocial factors may reduce the adaptive capacity of the individual, and consequently, the masticatory system, and predispose to TMD (deLeeuw and Klasser 2013a, Fillingim et al. 2013). Results from a case-control study indicate that management of stress and anxiety can mitigate the signs and symptoms of TMD (List et al. 2001). Depression, anxiety, psychological distress, and sleep dysfunction may influence TMD prognosis and symptoms (de Leeuw and Klasser 2013b). Behavioral factors such as somatization and depression influence TMD pain to a larger degree in girls than in boys. Higher pain intensity in the orofacial region correlated with greater impact on quality of life, including difficulty with prolonged jaw opening, eating hard/soft foods, and sleeping (Karibe et al. 2012).

2.10.5 Socioeconomics

There are associations between pain and family structure or socioeconomic status (SES). Socioeconomic factors, such as lower level of education, low income and unemployment are associated with higher rates of chronic and disabling pain (McBeth and Jones 2007). Headache prevalence was higher in children from low SES backgrounds, especially if mothers had a low level of education and if there was a positive family history of headache (Bugdayci et al. 2005). Furthermore, low SES is associated with abdominal pain (Kristjansdottir 1996a), but not with back pain in childhood (Kristjansdottir 1996b).

2.10.6 Genetics

Increasing evidence suggests that genetic factors contribute significantly to individual differences in responses to both clinical and experimental pain. Twin studies have demonstrated that genetic influences account for approximately 50% of the variance in chronic pain, and the existing data for experimental pain responses show comparable heritability estimates (MacGregor et al. 2004, Battie et al. 2007). Genetic factors seemed to play the most important roles in liability to neck pain in a study among 1,800 pairs of 11- to 12-year-old Finnish twins (Ståhl et al. 2013). Moreover, candidate gene association studies have identified multiple genes that may contribute to clinical and experimental pain. Several studies have shown that polymorphisms in genes affecting the function of both catecholaminergic and serotonergic systems may be associated with chronic pain disorders, such as TMD (Diatchenko et al. 2005). Fillingim et al. (2011) found that the presence of one low pain sensitivity catechol-Omethyl-transferase (COMT) haplotype decreased the risk of developing TMD.

2.10.7 Other factors

There is a relatively weak association between the development of TMD and occlusal factors (DeBoever, 2000; Taskaya-Yilmaz, 2004). Current literature does not support the theory that the development of TMD is either caused or improved by orthodontic treatment (Henrikson et al. 1999, Henrikson and Nilner 2003, Egermark et al. 2005). Moreover, repetitive strain such as playing a wind instrument or fingernail biting can be associated with TMD (Howard 2013).

2.11 CONSEQUENSES OF PAIN AND TEMPOROMANDIBULAR DISORDERS (TMD)

Pain and TMD, especially if under-treated, can have negative physiological and psychological consequences. Both the body and the brain can be permanently affected by long-term pain. There is evidence that when young children suffer from prolonged pain, the consequences are even more severe and long-lasting than in adults (McCance et al. 2006). Pain can interfere with all aspects of a child’s life. Moreover, for example increased pain sensitivity can cause altered pain responses such as hyperalgesia or decreased pain threshold (Desmeules et al. 2003, Lim et al. 2011). Depressed immune and inflammatory responses to pain can cause immune system changes such as increased risk of infection or delayed wound healing (Watkins and Maier 2000). One of the serious consequences of pain is its potential to impair choice. The tendency to rely on impulse to make choices, rather than systematic analysis, underlies numerous behaviors with individual and societal impacts, including addiction, overeating, and poor health behavior (Bickel et al. 2012, Lench and Bench 2015).

Pain can lead to psychological impairment and decreased quality of life. These associations are documented especially for children who experience chronic migraine. Children who suffer from migraine are more impaired than those who do not suffer from headaches, or even children who suffer from tension-type headache. Moreover, they used more medication and had more school nurse visits and school absences (Abu-Arefeh and Russell 1994, Perquin et al. 2000). Roth-Isigkeit et al. (2005) reported that approximately half of the subjects aged 4-18 had sleep problems, inability to pursue hobbies, eating problems, school absence, and inability to meet friends due to pain complaints. Further, the prevalence of restrictions in daily living attributable to pain increased with age.

Malocclusions, facial pain and TMD have been associated with impaired oral health-related quality of life (Rusanen et al. 2012). It has been shown that adolescents, especially girls with TMD pain, had more often depressive symptoms, school absences and need for pain medication than those without TMD pain (Nilsson et al. 2009). A recent study showed that children and adolescents 10-18 years of age with TMD pain seem to have higher frequencies of anxiety, depression, somatic problems, aggressive behavior and thought problems than children and adolescents without TMD pain (Al-Khotani et al. 2016a).

3 *The aims of the study*

The general aim of the study was to investigate the occurrence of pain complaints, temporomandibular disorders (TMD) and their risk factors in a population sample of Finnish children 6-8 years of age.

The specific aims were to investigate:

1. the prevalence of pain and signs of TMD *(Study I).*

2. the mutual relationships of pain and TMD conditions (*Study I,III*).

3. the associations of various types of lifestyle-related factors with different pain conditions *(Study II).*

4. the determinants for craniofacial pains *(Study III).*

4 Methods

4.1 ETHICAL ASPECTS

The study protocol was approved by the Research Ethics Committee of the Hospital District of Northern Savo. Participation in the study was voluntary, and both children and their parents gave their written informed consent. The individuals were not recognizable in the data and their personal data were kept confidential.

4.2 STUDY DESIGN AND STUDY POPULATION

The Physical Activity and Nutrition in Children (PANIC) Study is an ongoing physical activity and dietary intervention study in a population sample of children from the city of Kuopio, Finland (Figure 3).

Invitation letters were sent to the principal custodian of the children by mail according to the registration for first class of 16 public schools in the city of Kuopio. Private schools and classes providing preparing education for immigrant children and classes for children with severe special needs were excluded. The parents were asked to contact the study organization for participation. If the parents did not make contact, they were contacted by telephone. Altogether 736 children 6-8 years of age who started first grade in primary schools in Kuopio in 2007–2009 were invited to participate in the baseline examinations in 2007–2009. Of 736 invited children, 512 (70%) participated in the baseline study. Six children were excluded from the study at baseline because of physical disabilities that could hamper their participation in the assessments or the intervention or due to no time or motivation to attend the study. The remaining 506 children were divided into a combined physical activity and dietary intervention group (306 children, 144 girls, 162 boys) and a control group (200 children, 101 girls, 99 boys) based on their schools: to avoid non-intentional intervention in the control group, the intervention group only included children attending schools that were able to organize after-school exercise clubs for the children. The participants were also matched in the intervention and control groups according to the size (large vs. small) and location (urban vs. rural) of the schools to minimize differences in baseline characteristics between the groups. In the 16 public schools in Kuopio, the participation rate varied from 55 to 87%. The participants did not differ in sex distribution, age or BMI-SDS from the non-participants based on available school health examination data.

According to the study protocol, the first visit included a clinical examination and an exercise test, and participants were given a food record diary as well as questionnaires concerning physical activity and sedentary behavior to be filled by the parents. Also, for assessing sleep duration, the Actiheart-monitor was positioned on this first session. Two weeks after, at the second visit, a sleep questionnaire and questionnaire of psychological well-being were handed out to be completed at home. Two to four weeks after the first visit, body fat percentage and lean body mass were measured with DXA. At the same time period, a dental examination was performed and at that visit, a pain questionnaire was filled out by the parents.

The general aim of the PANIC Study was to identify the risk factors and risk groups for chronic diseases already in early childhood and to study the effects of physical activity, sedentary behavior, adiposity, diet, genetic factors, sleep and pain experience on health and well-being among children and later on also in adolescents. The whole set-up of the PANIC Study is presented in Figure 3. The present research project is based on a cross-sectional study design using the baseline measurement data of the PANIC Study.

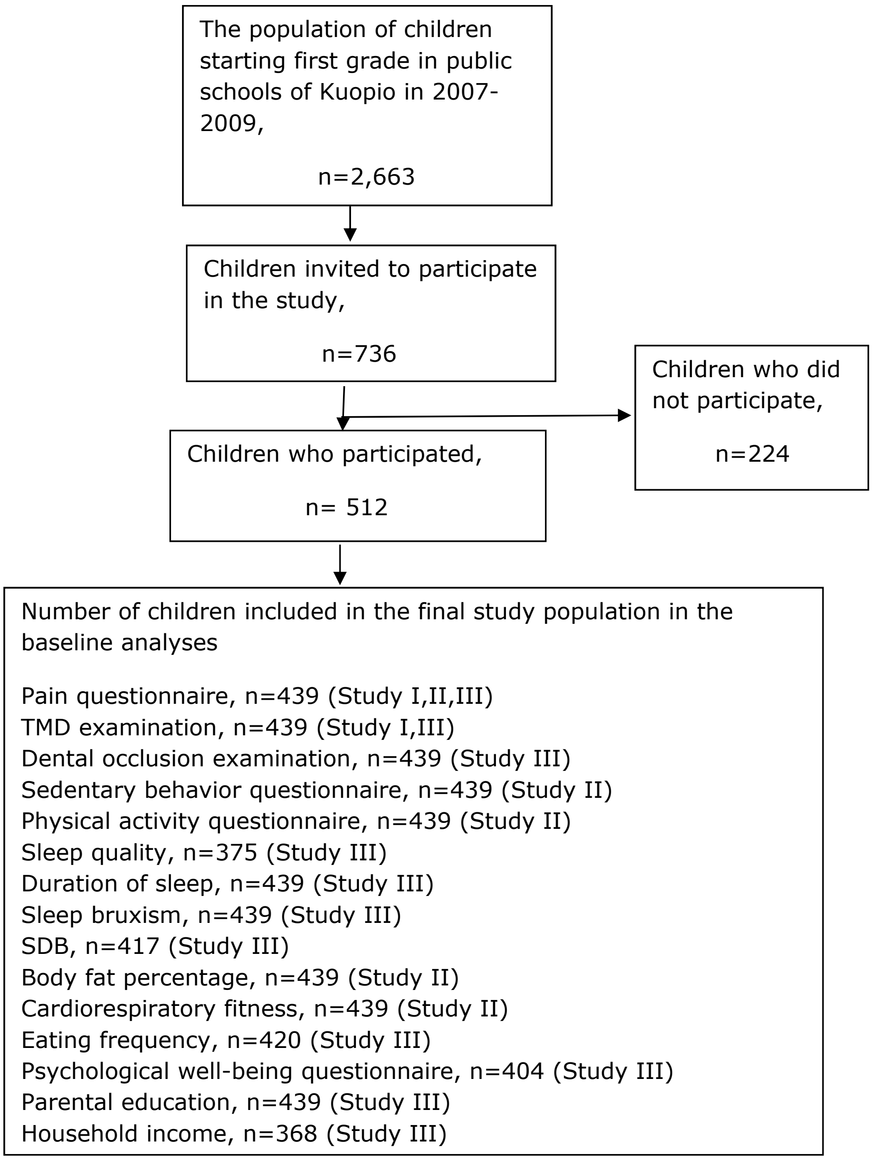

Figure 3. Flow chart of the Physical Activity and Nutrition in Children (PANIC) Study population at baseline in 2007-2009

4.3 ASSESSMENTS

4.3.1 Pain

Pain was assessed by a questionnaire filled out by the parents (*Study I,II,III*). The questionnaire was designed to assess the prevalence of pain conditions in general populations of children utilizing some of the questions of the pain questionnaire of the Finnish Association for the Study of Pain (www.skty.org). The parents filled out the questionnaire during their child's clinical dental examination or at home after the study visit and returned the questionnaire by mail. The parents were first asked 'Did your child have pain within the past three months (yes or no)' and then, 'How often did your child have pain within the past three months (never, seldom, once a month, several times a month, more than once a week, daily, or continuously)'. Thereafter, the parents were asked whether the pain was located in the head, neck-shoulder, abdomen, chest, pelvis, back, upper limbs or lower limbs. To specify, pain in the crown, occiput, forehead, temple, cheeks, temporomandibular joints and mandible on the right or left side was asked, and was defined as pain in the head (headache in *Study I and II*). Correspondingly, pain existing in the forehead, temple, cheeks, temporomandibular joints or mandible on the right or left side was asked, and pain existing in at least one area was defined as orofacial pain. Pain within the past three months was defined as frequent if it existed more than once a week overall. Moreover, the intensity of any pain and the highest intensity of pain and the most typical pain were asked using a numerical scale from 0 to 10 (0= no pain, 10= worst possible pain).

Morning headache was assessed using a sleep questionnaire filled out by the parents (Ikävalko et al. 2012). The questionnaire was partly based on a Finnish sleep questionnaire (Partinen et Gislason, 1995). The parents were asked how often their children had headache in the mornings (never, seldom, 1-2 times/week, 3-4 times/week, 6-7 times/week). The children were defined to have morning headache if it existed at least once a week.

Pain existing in at least two different areas of the body during the past three months, regardless of its frequency, was defined as multiple pain (Perquin et al. 2000). Children who reported pain in an upper extremity, a lower extremity, and either neck, back, or chest were defined as suffering from widespread pain (WSP) (White et al. 1999).

Moreover, the questionnaire included items on pain in daily activities (at rest, during exercise) and at different times of the day (morning, daytime, evening, night, or all day) as well as the fluctuation of pain. Restrictions in daily activities (drinking, eating, talking, sleeping, playing, hobbies, or school attendance) because of pain were also asked with a numerical scale ranging from 0 to 10 and were categorized as no (0), a little (1–3), moderately (4–7), a lot (8–9), and totally (10). Furthermore, the parents were asked about the child's use of pain medication (yes or no) and visits to a physician due to pain (yes or no).

4.3.2 Oral health

Assessment of TMD

All clinical examinations were carried out by one dentist who was trained by a TMD specialist before the beginning of the study (*Study I,III*). During the examinations the subjects were in half sitting position. At the beginning of each examination day, a digital scale was used to ensure that approximately the same pressure was applied during the palpation of the muscle sites (1 kg) and the joints (0.5 kg) in each clinical examination. The recorded findings included mouth opening limitation, deviation in mouth opening movement, palpation tenderness in masticatory muscles and temporomandibular joints, pain in mandible movements, and joint sounds.

In assessing mouth opening limitation, the child was asked to place the mandible in a comfortable position and first to open the mouth as far as possible without feeling any pain (unassisted opening without pain) and then to open the mouth as wide as possible, even if he/she felt pain (maximum unassisted opening). The opening was recorded with a millimeter ruler at the incisal edge of the maxillary central incisor that was the most vertically oriented and measured vertically to the labioincisal edge of the opposing mandibular incisor in maximum unassisted opening. Vertical incisal overlap was added to the actual value of mouth opening. A mouth opening < 35 mm was considered to represent an opening limitation (Pahkala et al. 1991).

When assessing deviation in mouth opening movement, the subject was asked to position the mandible in a comfortable position and to open the mouth as wide as possible three times. The opening pattern was assessed and scored as straight, lateral deviation to right or left, or corrected deviation ("S" deviation).

The muscles were palpated using the fingertips for extraoral muscles. Intraoral muscle palpation was not done because of technical difficulties related to the subjects' young age. The muscles were palpated while the clinician's opposite hand was used to brace the head to provide stability. The child's mandible was in resting position, without the teeth touching, and the muscles were in a passive state. The posterior, middle, and anterior temporal muscle as well as origin, body, and insertion of masseter muscle were bilaterally palpated. The posterior mandibular region (posterior digastric muscle) and submandibular region (anterior digastric muscle) were bimanually and bilaterally palpated.

The joints were laterally palpated using the fingertips. The child was asked to open slightly until the lateral pole of the condyle translated forward. The joints were also palpated from the posterior side by placing the fingertips into the child's external meatus and asking the child to slightly open and close the mouth.

Palpation tenderness in muscles and joints was evaluated with the Faces Pain Scale -Revised (FPS-R) (Figure 4) (*Study I,III*), which is a commonly used metric measure of pediatric pain, and was graded from 0 to 10 as no pain (0), mild pain (1–3), moderate pain (4–7), and severe pain (8–10) (www. painsourcebook.ca). The children chose the face that best depicted the pain they were experiencing and the researcher converted it to a numerical value (0-10). Children with scores 1–10 were defined as having a painful sign of TMD. Pain in mandibular movements was also measured. The children were asked if they felt pain on maximal unassisted mandibular opening or on excursive movements (right/left lateral excursion and protrusion), recording whether or not they felt any pain and its location (right/left side in the joint); this was defined as a painful sign of TMD.

Finally, when measuring temporomandibular joint sounds, the children were asked to open and close the mouth three times. Temporomandibular joint sounds were registered on palpation for vertical range of motion as well as by auscultation with a stethoscope on opening or closing and were classified as clicking or crepitation. Temporomandibular joint sounds on palpation for lateral excursions and protrusion were registered on palpation by fingertips, but not scored. Three of these six examinations (deviation in mouth opening, palpation tenderness in temporomandibular joints, pain in mandibular movements) were based on the Research Diagnostic Criteria for TMD (RDC/TMD, Axis I). Three examinations differed slightly from RDC/TMD as follows: due to the subjects' young age, a maximum unassisted mouth opening of < 35 mm was considered to represent an opening limitation instead of < 40 mm as defined in the RDC/TMD. Intraoral palpation of the lateral pterygoid muscle and tendon of the temporalis muscle were not done because of technical difficulties related to the subjects' young age. The presence of joint sounds was examined by auscultation with a stethoscope instead of palpation by fingers as defined in the RDC/TMD (Dworkin and LeResche 1992). For analyses, each of the six findings was recorded as either present or absent by grouping the clinical signs of TMD as (1) "at least one of the six signs," (2) "at least one sign excluding deviation," (3) "painful TMD signs," or (4) "nonpainful TMD signs" *(Study I,III)*.

Finally, trapezius muscles were bilaterally palpated and palpation tenderness was evaluated with FPS-R as described above.

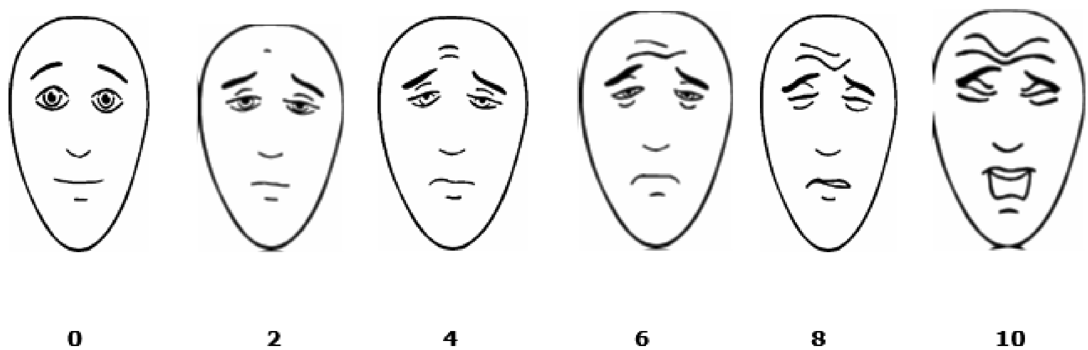

Figure 4. Faces Pain Scale –Revised used in the present study (*Study* I,III).

Dental occlusion and other craniofacial features and sleep bruxism

Craniofacial morphology and dental occlusion were clinically evaluated by a standard orthodontic screening method by one orthodontist right after the clinical oral examination. The occlusion was assessed in the intercuspal position according to the modified method of Björk (Björk et al. 1964). The use of occlusal appliances was recorded during the dental clinical examination.

The question of sleep bruxism was asked in a sleep questionnaire (Ikävalko et al. 2012). Bruxism was defined if it existed at least once a week.

4.3.3 Anthropometric factors, body composition

The children were without shoes and used light clothing during the assessment of body height and weight. Body height was measured in the Frankfurt plane by a wall-mounted stadiometer to an accuracy of 0.1 cm (Haapala 2013). Body weight was measured by a calibrated InBody 720 bioimpedance device (Biospace, Seoul, Korea) to an accuracy of 0.1 kg after overnight fasting and after emptying the bladder.

Body mass index (BMI) was calculated by dividing body weight (kg) by body height squared (m2). Body mass index - standard deviation score (BMI-SDS) was calculated using Finnish references (Saari et al. 2011). Body fat percentage and lean body mass were measured with the Lunar® dual-energy X-ray absorptiometry (DXA) device (Lunar Prodigy Advance; GE Medical Systems, Madison, Wisconsin, USA) at the Department of Clinical Physiology and Nuclear Medicine, Kuopio University Hospital. Overweight and obesity were defined using the age- and sex-specific BMI cutoffs derived from growth curves corresponding to BMI values 25 and 30 in adults 18 years of age (Daniels et al. 2005).

The pubertal stage of the children was assessed by Tanner criteria in a medical examination (Marshall and Tanner 1969, 1970, Mäntyselkä et al. 2014).

4.3.4 Life-style related factors

Sedentary behavior

Sedentary behavior, excluding sedentary behavior at school, was assessed by the PANIC Physical Activity Questionnaire filled out by the parents (Eloranta et al. 2011, Haapala et al. 2014). The questionnaire included items on screen-based sedentary behavior (watching TV and videos, using a computer, playing video games, using a mobile phone, playing mobile games), sedentary behavior related to academic tasks (reading, writing), sedentary behavior related to arts, crafts and games (drawing, doing arts and crafts, playing board and card games), sedentary behavior related to music (listening to music, playing music) and sitting and lying for rest. Time spent in each sedentary behavior was asked separately for weekdays and weekend days and was expressed in minutes per day. The amount of total sedentary behavior was calculated by summing up the times spent in each sedentary behavior and was expressed in minutes per day weighted by the number of weekdays and weekend days.

Physical activity

Physical activity, excluding physical education at school, was assessed by the PANIC Physical Activity Questionnaire filled out by the parents (Väistö et al. 2014, Haapala et al. 2014). The questionnaire included items on organized sports, supervised exercise organized by sports associations, unsupervised physical activity, physically active school transportation and physical activity during recess. The frequency and duration of a single session of each type of physical activity were asked. The amount of each physical activity type was calculated by multiplying the frequency of the activity with the duration of a session and expressed in minutes per day. Total physical activity was calculated by summing up the amounts of each type of physical activity and was expressed in minutes per day. All children in the first grade in the schools of the city of Kuopio had 90 minutes of physical education per week, which was included in total physical activity.

The PANIC Physical Activity Questionnaire was validated using the Actiheart monitor (Actiheart, CamNtech, Cambridge, UK) combining heart rate and accelerometer measurements in a subsample of 38 children examined at baseline of the PANIC Study (Väistö et al. 2014). Total physical activity measured by the questionnaire correlated positively with total physical activity measured by the Actiheart monitor ($r = 0.37$, $p= 0.033$).

Cardiorespiratory fitness (CRF)

CRF was assessed by a maximal exercise stress test using an electromagnetic Ergoline® cycle ergometer and a pediatric saddle module (Ergoselect 200 K, Ergoline, Bitz, Germany). The exercise tests were carried out by a physician and trained research nurses in the exercise test laboratory of the Institute of Biomedicine at the University of Eastern Finland. The exercise test protocol included a three-minute warm-up period with a workload of five Watts, a one-minute steady-state period with a workload of 20 Watts, an exercise period with a workload increase of one Watt per six seconds until voluntary exhaustion, and a four-minute cooling-down period with a workload of five Watts (Lintu et al. 2014). The children were asked to keep the cadence stable within 70–80 rounds per minute with a minimum of 65 rounds per minute. The children were verbally encouraged to exercise until voluntary exhaustion. The exercise test was considered maximal if the reason for terminating the test indicated maximal effort and maximal cardiovascular capacity. CRF was measured by maximal workload in Watts divided by lean body mass in kilograms.

Sleep duration and quality, sleep-disordered breathing (SDB)

Sleep duration was assessed by the Actiheart monitor (Cambridge Neurotechnology Ltd, Cambridge, UK). The Actiheart is a single-piece combined heart rate and movement monitor which was set to record in 60-second epochs (Brage et al. 2005). It was positioned on the chest with two standard electrocardiogram (ECG) electrodes (Bio Protech Inc, Seoul, Korea). Sleep duration registering varied between one and seven days, and it was at least two days in 85% of the children.

The quality of sleep was assessed by a questionnaire completed by the parents (Partinen and Gislason 1995, Ikävalko et al. 2012). The parents were asked how their child usually slept after falling asleep (1= very peacefully, 2= quite peacefully, 3= sometimes peacefully and sometimes restlessly (mixed), 4= quite restlessly, 5= very restlessly). Children with scores 3–5 were defined as having restless sleep.

Sleep-disordered breathing, SDB, was assessed by a questionnaire administered to the parents (Partinen and Gislason 1995, Ikävalko et al. 2012). The parents filled out the questions regarding the child's symptoms of SDB and upper airway infections and previous operative treatments, such as adenotonsillectomy. SDB was defined as apneas, frequent or loud snoring or nocturnal mouth breathing observed by the parents.

Dietary factors

The dietary intake of the children was assessed by food records on four consecutive days (Eloranta et al. 2011). Records of two weekdays and two weekend days and those of three weekdays and one weekend day were included in the analyses. Breakfast, lunch and dinner were classified as main meals and all in-between eating and drinking occasions as snacks. Skipping one or more main meals during the four-day recording was coded as skipping main meals

Psychological well-being

The parents filled out a questionnaire concerning the child's well-being during the last three months. There were 19 items describing psychological wellbeing (i.e., timidity, tearfulness, uncertainty, anxiety, frustration, depression, restlessness, squeamishness or anger, aggressiveness, difficulties in concentration, problems in concentration on homework, difficulties in homework, unwillingness to go to school, troublemaking in class, discouragement, feeling of inferiority, forgetting things, sleeping disorders, difficulties doing the same things as others of the same age). Each item was rated on a 5-point scale (0=not at all, 1=once or twice during the previous 3 months, 2=sometimes, 3=often, 4= every day or almost every day). The psychological well-being score was calculated summing up the scores of each item and it ranged from 0 to 76. A higher score indicated lower well-being.

Family characteristics

The annual household income (≤€30,000, €30,001–60,000, ≥€60,001) and the level of education in the family based on the highest completed or ongoing degree (vocational school or less, vocational high school, university) were inquired by a questionnaire. If the parents reported different categories, the higher category was used in the analyses.

4.4 STATISTICAL METHODS

Statistical analyses were performed using the SPSS statistical software for Windows versions 14.0–21.0 (SPSS Inc, Chicago, IL, USA) and SAS version 9.1.3 (SAS). All associations and differences in averages were considered statistically significant if the p-value was <0.05.

Differences between the prevalence of at least one sign of TMD and the location or frequency of pain were evaluated using the chi-square test (*Study I*). Chi-square tests were also applied to study the associations between the prevalence, frequency, and location of pain and gender, the use of medication, and visits to a physician (*Study I*) and the differences in the prevalence of any pain, frequent pain, multiple pain, and pain in the eight areas of the body between girls and boys (*Study II*). Chi-square statistics were also used to analyze differences in the prevalence of eating frequency, crossbite, occlusal appliance, sleep quality, sleep bruxism, SDB, family income, parental education and different pains between girls and boys (*Study III*).

Independent samples t-test was used to compare the differences in total sedentary behavior and components, total physical activity and components, cardiorespiratory fitness, and body fat content between girls and boys (*Study II*). Also differences in age, sleep duration and psychological well-being between girls and boys were analyzed with the independent samples t-test (*Study III*).

Multivariate logistic regression analyses were applied to study associations of the potential determinants with the existence of different pain conditions and the risk of having clinical signs or painful signs of TMD (*Study I,III*), but also used to investigate all those determinants that significantly contributed to any of the pains in logistic regression analyses (*Study III*). Before multinomial analyses, correlations between potential determinants were checked, and sleep quality and bruxism were found to correlate (c=0.165 at the level 0.01) (*Study III*).

Multivariate logistic regression analyses were also used to investigate the association of each lifestyle-related variable (total sedentary behavior and components, total physical activity and components, cardiorespiratory fitness, and body fat content) with different pain conditions (*Study II*).

The results from the logistic regression analyses are presented in terms of odds ratios (ORs), together with 95% confidence intervals (CIs) (*Study I,II,III*).

5 Results

5.1 BASIC CHARACTERISTICS

The characteristics of the children are presented in Table 4. Of the 439 children, 208 were girls and 231 boys. Altogether 17% of the girls and 11% of the boys were overweight or obese. According to Tanner criteria (Marshall and Tanner 1969, 1970), only 2% of the girls and 2% of the boys were pubertal.

Defined by the highest educational background of the family member, 19% of the families had a vocational school degree or less, 44% had a vocational high school degree, and 36% had a university degree. Annual household income was ≤ €30,000 in 18% of the families, €30,001-€60,000 in 35% and >€60,000 in 31%.

Girls had higher body fat percentage (%) than boys. Further, girls had higher levels of total sedentary behavior, sedentary behavior related to academic skills or to arts, crafts and games or to music than boys. However, girls had lower levels of screen-based sedentary behavior, total physical activity, supervised exercise organized by sports associations, unsupervised physical activity, physical activity during recess and cardiorespiratory fitness than boys (Table 4).

Table 4. The basic characteristics of the children at the baseline in 2007-2009

	All children (n=439)	**Girls (n=208)**	**Boys (n=231)**	**p-value**
Age (years)	7.6 (0.4)	7.6 (0.4)	7.6 (0.4)	0.270
Body height (cm)	128.7 (5.7)	128.0 (5.6)	129.6 (5.6)	**0.002**
Body weight (kg)	27.1 (5.1)	26.8 (5.2)	27.4 (5.1)	0.191
Weight status				
Normal weight, number of children (%)	377 (86%)	177 (83%)	200 (89%)	
Overweight, number of children (%)	39 (9%)	25 (12%)	14 (6%)	
Obese, number of children (%)	22 (5%)	10 (5%)	12 (5%)	0.123
Body fat percentage (%)	20 (8.4)	22.8 (7.9)	17.4 (8,1)	**<0.001**
BMI-SDS	-0.14 (1.09)	-0.12 (1.10)	-0.16 (1.09)	0.675
Puberty[a], number of children (%)	9 (2%)	5 (2%)	4 (2%)	0.648
SEDENTARY BEHAVIOR				
Total sedentary behavior (min/d)	214 (103)	227 (106)	201 (99)	0.009
Screen-based sedentary behavior (min/d)	103 (53)	92 (47)	113 (57)	**<0.001**
Sedentary behavior related to academic tasks (min/d)	30 (31)	36 (32)	26 (30)	**0.001**
Sedentary behavior related to arts, crafts and games (min/d)	53 (45)	68 (49)	40 (36)	**<0.001**
Sedentary behavior related to music (min/d)	17 (27)	22 (31)	13 (22)	**<0.001**
Sitting and lying for a rest (min/d)	10 (25)	10 (26)	10 (24)	0.922
PHYSICAL ACTIVITY				
Total physical activity (min/d)	111 (41)	105 (38)	116 (43)	**0.005**
Organized sports (min/d)	9 (12)	8 (12)	9 (12)	0.140
Supervised exercise organized by associations (min/d)	15 (17)	13 (14)	17 (19)	**0.024**
Unsupervised physical activity (min/d)	49 (31)	45 (31)	53 (31)	**0.003**
Physically active school transport (min/d)	25 (23)	27 (24)	24 (22)	0.176
Physical activity during recess (min/d)	22 (6)	22 (6)	23 (6)	**0.005**
LIFESTYLE-RELATED FACTORS				
Cardiorespiratory fitness (W/kg of lean mass)	3.68 (0.52)	3.55 (0.51)	3.80 (0.50)	**<0.001**
Sleep duration (h/d)	9.6 (0.5)	9.7 (0.5)	9.6 (0.5)	0.279
Sleep quality				
Peaceful/quite peaceful sleep	307 (70)	146 (70)	161 (70)	
Restless sleep	68 (16)	35 (17)	33 (14)	0.559
Sleep bruxism				
No	245 (56)	116 (56)	129 (56)	
Yes	194 (44)	92 (44)	102 (44)	0.987
Sleep-disordered breathing				
No	375 (85)	180 (87)	195 (84)	
Yes	42 (10)	18 (9)	24 (10)	0.527
Eating meals				
3 meals daily	163 (59)	81 (39)	82 (36)	
< 3 meals daily	257 (37)	121 (58)	136 (59)	0.602
SOCIOECONOMIC STATUS				
Household income				
≤€30,000	78 (18%)	46 (26%)	32 (17%)	
€30,001–60,000	155 (35%)	67 (38%)	88 (46%)	
≥€60,001	135 (31%)	64 (36%)	71 (37%)	0.074
Parental education				
vocational school or less	84 (19%)	37 (18%)	47 (20%)	
vocational high school	195 (44%)	93 (45%)	102 (44%)	
university	157 (36%)	75 (37%)	82 (36%)	0.832

Values are means (2 SDs) and percentiles for normally distributed variables. Gender differences were analyzed with independent samples t test and χ2 test.

[a]Prevalence of puberty based on Tanner (Marshall and Tanner 1969, 1970).

BMI-SDS = body mass index - standard deviation score calculated using Finnish references (Saari et al., 2011)

5.2 PREVALENCE AND OTHER FEATURES OF PAIN COMPLAINTS

Of the children, 54% had experienced any pain on a weekly basis (Table 5). Pain was most prevalent in the lower limbs (36%) and head (31%). About a fourth of the children had orofacial pain and almost a fifth had morning headache. Over half of the children with pain had more than one location of pain (multiple pain), the combination of headache and lower limb pain being the most prevalent. Only 14 children fulfilled the criteria of having WSP.

Pain was most common in evenings. In general, the intensity of pain typically varied between 2 and 6 (score 0–10) and the highest intensity varied between 4 and 8 (*Study I*). Pain medications had been used by 61% of the children with pain symptoms, especially those with lower limb pain, headache, neck-shoulder pain and abdominal pain, and 16% had visited a physician due to pain.

Table 5. Prevalences of different pain complaints during the last 3 months (*Study I,II,III*).

	All children (n=439)	**Girls (n=208)**	**Boys (n=231)**	**p-value**
	Number of children (%)			
Any pain	235 (54%)	121 (56%)	114 (50%)	0.150
Frequent pain	124 (28%)	63 (30%)	61 (27%)	0.508
Multiple pain	128 (29%)	63 (30%)	65 (29%)	0.803
Widespread pain	14 (3%)	8 (4%)	6 (3%)	0.736
Lower limb pain	158 (36%)	83 (37%)	75 (35%)	0.591
Headache	138 (31%)	70 (33%)	68 (30%)	0.532
Morning headache	73 (17%)	33 (16%)	40 (17%)	0.454
Orofacial pain	115 (26%)	52 (26%)	63 (27%)	0.320
Abdominal pain	79 (18%)	45 (20%)	34 (15%)	0.089
Neck-shoulder pain	27 (6%)	13 (6%)	14 (6%)	0.988
Upper limb pain	26 (6%)	15 (7%)	11 (5%)	0.323
Back pain	17 (4%)	9 (4%)	8 (4%)	0.696
Chest pain	7 (2%)	5 (4%)	2 (1%)	0.217
Pelvic pain	7 (2%)	5 (4%)	2 (1%)	0.217

Gender differences were analyzed with χ^2 test. P-value represents differences between girls and boys.

5.3 CLINICAL TEMPOROMANDIBULAR FINDINGS

On clinical examination, 35% of the subjects had at least one of the signs of TMD and 13% had painful signs. The most common clinical signs were deviation in mouth opening, sounds in temporomandibular joints and palpation tenderness in masticatory muscles (Figure 4). There was no difference between girls (n=90, 18.6%) and boys (n=81, 16.8%) in the proportion having at least one clinical sign of TMD. Of the children, 15% had dental crossbite and 7% had an occlusal appliance.

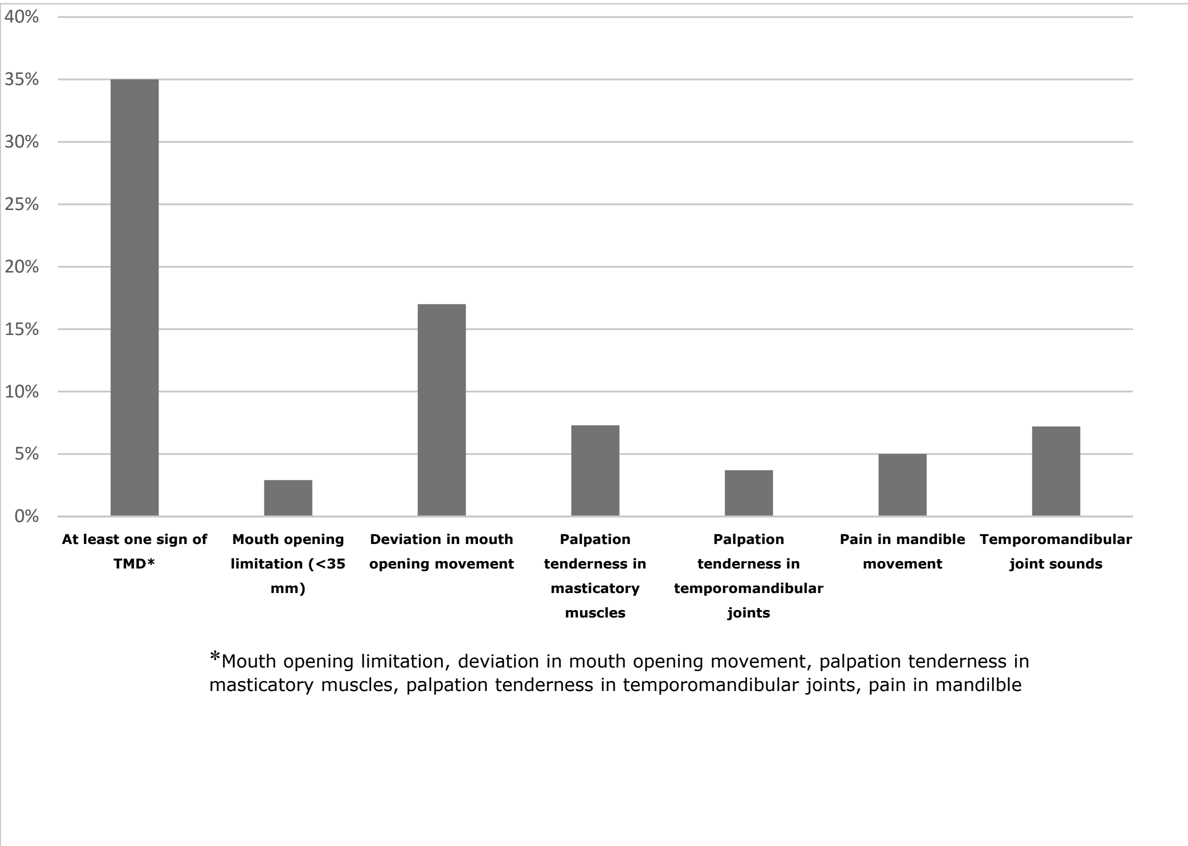

Figure 4. Prevalences (%) of signs of temporomandibular disorders (TMD) among 483 subjects (234 girls and 249 boys).

5.4 CONSEQUENCES AND DETERMINANTS OF PAIN COMPLAINTS AND TEMPOROMANDIBULAR DISORDERS (TMD)

More than half of the children had pain complaints both at rest and during exercise. Pain affected sleeping in 67%, playing in 67%, other hobbies in 58%, eating in 39%, school activities in 37%, drinking in 19% and speaking in 19% of the children. Two thirds of the children who experienced pain also had disturbed sleep because of pain.

High levels of sedentary behaviors, low cardiorespiratory fitness or low body fat content were associated with increased likelihood of any pain. Also, low body fat content was associated with increased risk of lower limb and multiple pain. Moreover, low cardiorespiratory fitness was associated with increased likelihood of headache (Table 6). Physical activity or the prevalence of overweight or obesity were not associated with the risk of any pain condition.

Table 6. Odds ratios (95% confidence intervals) of having pain in sex-specific thirds of sedentary behavior, cardiorespiratory fitness and body fat percentage in children. (*Study II*).

	Any pain[a] OR (95% CI)	**Frequent pain[b] OR (95% CI)**	**Multiple pain[c] OR (95% CI)**	**Lower limb[a] pain OR (95% CI)**	**Headache[a]**	**Abdominal pain OR (95% CI)**
Sedentary behavior (min/d)						
Low (Girls <170; Boys <149)	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Medium (Girls 170-246; Boys 149-221)	1.34 (0.83-2.18)	1.15 (0.68-1.96)	1.02 (0.60-1.73)	1.43 (0.87-2.38)	1.02 (0.60-1.73)	1.40 (0.73-1.73)
High (Girls >246; Boys >221)	**1.95 (1.20-3.17)**	1.15 (0.68-1.96)	1.21 (0.72-2.03)	1.41 (0.86-2.33)	1.66 (1.00-2.77)	1.64 (0.87-3.11)
P-value for trend across thirds	**0.007**	0.614	0.476	0.178	0.052	0.127
Cardiorespiratory fitness (W/kg of LM)						
Low (Girls <3.31; Boys <3.36)	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Medium (Girls 3.31-3.77; Boys 3.36-4.02	0.78 (0.48-1.28)	1.18 (0.69-1.99)	0.85 (0.51-1.43)	0.81 (0.49-1.33)	0.80 (0.48-1.33)	1.19 (0.66-2.14)
High (Girls >3.77; Boys >4.02)	**0.54 (0.32-0.91)**	0.95 (0.54-1.68)	0.60 (0.34-1.05)	0.75 (0.44-1.27)	0.50 (0.28-0.87)	0.58 (0.29-1.18)
P-value for trend across thirds	**0.019**	0.858	0.074	0.287	0.015	0.134
Body fat percentage (%)						
Low (Girls <18.6; Boys <12.3)	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Medium (Girls 18.6-25.2; Boys 12.3-18.9)	0.67 (0.41-1.09)	0.68 (0.40-1.15)	**0.54 (0.32-0.91)**	**0.57 (0.35-0.94)**	0.62 (0.37-1.04)	0.80 (0.43-1.48)
High (Girls >25.2; Boys >18.9)	**0.56 (0.34-0.93)**	0.83 (0.49-1.41)	**0.51 (0.30-0.86)**	**0.52 (0.31-0.86)**	0.63 (0.38-1.06)	0.70 (0.37-1.31)
P-value for trend across thirds	**0.023**	0.497	**0.011**	**0.010**	**0.082**	0.265

Data are odds ratios (OR) and their 95% confidence intervals (95% CI) from logistic regression models adjusted for age and other lifestyle factors in the table.
[a]Pain during the past 3 months reported by the parents
W = Watts; LM = lean body mass

Children in the highest sex-specific third of sedentary behavior related to academic tasks (reading and writing) had a 2.1-fold higher risk of frequent pain and a 2.0-fold higher risk of headache than children in the lowest third. Those in the highest sex-specific third of sedentary behavior related to arts, crafts and games had a 1.8-fold higher risk of any pain, a 1.8-fold higher risk of multiple pain, a 1.8-fold times higher risk of lower limb pain, a 2.1-fold higher risk of headache and a 1.8-fold higher risk of abdominal pain than children in the lowest third.

Restless sleep was associated with increased risk of orofacial pain and with headache (Figure 5). Restless sleep, sleep bruxism and skipping meals were related to increased risk of morning headache (*Study III*), (Figure 5). Moreover, children in the middle household income class (€30,001-60,000) had a 53% (OR 0.47, CI 0.25–0.87) and in the highest household income (≥€60,001) a 62% (OR 0.38, 0.20–0.73) lower risk of morning headache than children in the lowest household income category (≤€30,000).

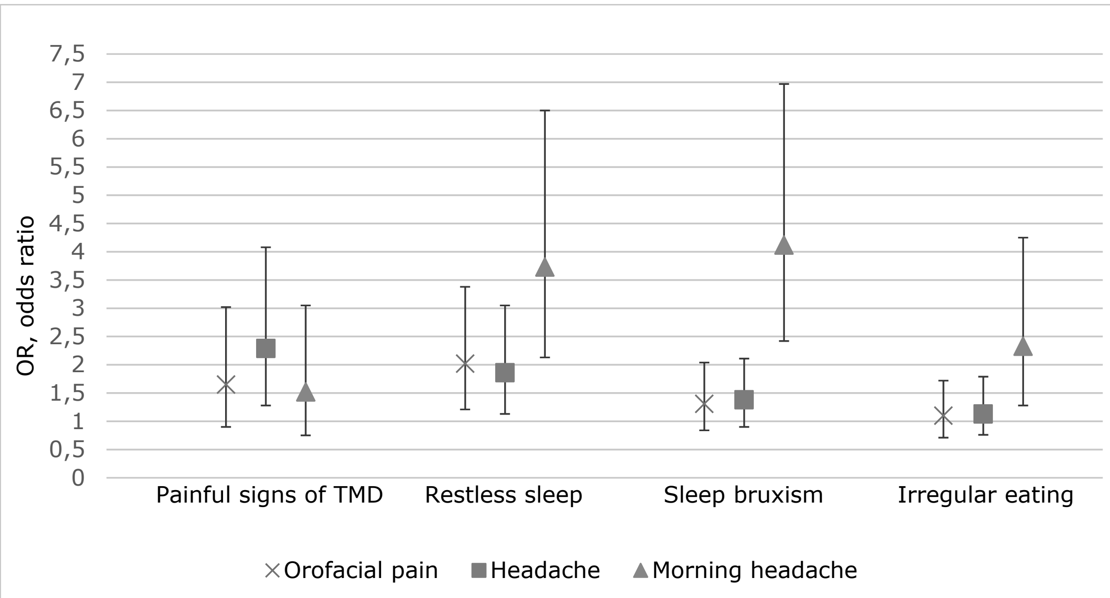

Figure 5. Determinants for craniofacial pains among 439 children after adjustment for age and gender (*Study III*).

Children with at least one sign of TMD had a 12.1-fold higher risk of suffering from palpation tenderness in the trapezius muscles than those without TMD sign/signs. Furthermore, children who reported back pain, headache or neck-shoulder pain were more likely to have clinical signs of TMD than those without such symptoms (Table 7). Moreover, children with headache had a 2.25 times higher risk of painful signs of TMD than children without headache (*Study I*). Sleep bruxism, dental crossbite or use of oral appliance was not associated with TMD signs.

Table 7. ORs (95% CIs) for risk of having at least one clinical sign of TMD* among children with various pain conditions (n=226) (*Study* I).

Pain condition	Number of subjects with the indicated pain condition	OR (95% CI)	p-value#
Headache	135	1.6 (1.1-2.5)	**0.02**
Neck-shoulder pain	27	2.7 (1.2-6.0)	**0.01**
Upper limb pain	26	2.1 (0.9-4.6)	0.08
Chest pain	7	0.6 (0.1- 3.3)	0.59
Back pain	17	3.0 (1.1-8.5)	**0.04**
Abdominal pain	74	0.8 (0.5-1.4)	0.55
Pelvic pain	7	0.8 (0.1-4.5)	0.81
Lower limb pain	150	1.5 (1.0-2.3)	0.06

* Mouth opening limitation (<35 mm), deviation in mouth opening movement, palpation tenderness in masticatory muscles or in temporomandibular joints, pain in mandible movements, temporomandibular joint sounds
#statistically significant p-values are presented in bold

6 Discussion

6.1 SUMMARY OF FINDINGS

The main finding of this study was that bodily pain complaints and clinical signs of TMD are common among children 6-8 years of age in Finland. Moreover, an important finding was that a number of life-style related factors, such as high levels of sedentary behavior, low cardiorespiratory fitness and low body fat content were associated with increased likelihood of pain in general. This thesis shows that children who reported back pain or pain in head-shoulder area or had palpation tenderness in the trapezius muscles were more likely to have clinical signs of TMD than those without such symptoms. Moreover, restless sleep, skipping meals and sleep bruxism were related to increased likelihood of headache.

6.2 PREVALENCE OF PAIN AND CLINICAL SIGNS OF TEMPOROMANDIBULAR DISORDERS (TMD)

Of single pains, pain in the lower limbs and head was most prevalent. These findings are in accordance with the results of previous studies indicating that recurrent lower limb pain that is usually related to growth constitutes the most frequent musculoskeletal pain in children at this age (Evans and Scutter 2004, Kaspiris and Zafiropoulou 2009). Headache is also recognized as a major pediatric pain problem (van Dijk et al. 2006). In this study, pain in the head was divided into headache and orofacial pain, and headache in the morning was also assessed. By making these classifications it was easier to assess confounding factors. About one fourth of the children had orofacial pain; the finding is in line with previous studies among children (Manfredini et al. 2011, Kumar et al. 2016). Furthermore, almost one fifth of them reported morning headache. There are no studies to compare this finding to because no previous studies on the prevalence of morning headache in children were found. The reported prevalence of morning headache in adults varies widely in the literature, from 4% to as high as 60%, mostly due to differences in the populations studied and whether they had obstructive sleep apnea syndrome (Göder et al. 2003, Kristiansen et al. 2012, Suzuki et al. 2015).

Half of the children with pain had multiple pain, the most prevalent combination being headache and lower limb pain. A similar prevalence of multiple pain was found in a study among children and adolescents 0-18 years of age, in which the most frequent combination was headache and abdominal pain (Perquin et al. 2000a). It seems that headache, lower limb pain, abdominal pain and back pain are the most common combinations of multiple pain in children and adolescents. Accordingly, Kristjansdottir and coworkers (1997) found that among adolescents 11-16 years of age, the most frequent combination was headache, stomach pain and back pain, and that the prevalence of multiple pain was 15.6% on a weekly basis. In the present study, 3% of the children fulfilled the criteria of WSP. There are no studies to compare this finding to, because no previous studies on the prevalence of WSP in children of similar age were found. However, other studies suggest that the prevalence of WSP increases with age. It has been found that the prevalence of WSP increased from 8% at the age of 10–12 years to 15% at the age of 14–16 years (Mikkelsson et al. 2008).

More than one third of the children had at least one clinical sign of TMD. The present study is in line with the previous studies showing that clinical signs of TMD are common in children of the same age as in the present study (Vanderas and Papagiannoulis 2002, Farsi 2003). One explanation for the finding might be that almost all children had mixed dentition and thus the first stage of eruption of the permanent teeth was ongoing. It has been shown that parafunctional habits, such as bruxism, are common in children, especially at the time of mixed dentition, and have been associated with TMD (Sari and Sonmez 2002). Although sleep bruxism was a common finding in the present study, it was not associated with TMD. The high prevalence of TMD might also be due to immature muscle co-ordination as described below.

Studies among children and adolescents show that the most common clinical signs of TMD are joint sounds, impaired movement of the mandible and limited mouth opening (Toscano and Defabianis 2009). The present study is in line with a previous study showing that the most frequent clinical sign of TMD was deviation in mouth opening movement (Pereira et al. 2009). However, it has to be taken into account that the deviation, especially in children, may represent a normal variation, perhaps due to immature muscle co-ordination or a slight anatomical asymmetry in the joint area, rather than a manifestation of TMD. As found also previously, among children and adolescent with signs of TMD (Bonjardim 2005), temporomandibular joint sounds as well as palpation tenderness in masticatory muscles were prevalent in the present study, too. Furthermore, more than a tenth of the children had at least one painful sign of TMD.

6.3 DETERMINANTS OF PAIN AND TMD SIGNS

There are few studies on the associations of lifestyle-related factors with pain conditions in children and the results of those studies have been inconsistent (Wedderkopp et al. 2003, Bektas et al. 2015). In the present study, children with high levels of sedentary behaviors, low cardiorespiratory fitness or low body fat content had increased likelihood of any pain. The present study provides the first evidence on the associations of different sedentary behaviors with pain conditions in children. It was found that drawing, doing arts and crafts, playing board and card games, and reading and writing were associated with several pain conditions. Taken together, the results of earlier studies in adolescents (Hakala et al. 2006, Paananen et al. 2010, Torsheim et al. 2010) and the present findings in children suggest that sedentary behaviors related to sitting are associated with pain conditions in youth. However, causal inferences cannot be drawn because of the cross-sectional design of the study. Sitting is known to increase muscle tension in the neck, shoulder and low back areas and may thereby cause musculoskeletal pain and headache (Swain et al. 2015). One reason for the association between sedentary behavior and musculoskeletal pain could be that some children have musculoskeletal problems that cause pain and make them prefer sitting.

In contrast to some earlier studies indicating that pain in the lower limbs is more prevalent in overweight and obese children and adolescents (Stovitz et al. 2008, MacFarlane et al. 2011), in the present study no associations of prevalent overweight or obesity with any pain condition were found. One reason for this may be that only 9% of the children were overweight and 5% obese. Therefore, obese, overweight and normal weight children could not be fully compared, which is why sex-specific thirds of body fat percentage were used and assessed by the DXA method which is a more accurate measure of body fat content than prevalent overweight or obesity. Surprisingly, children with low body fat percentage had increased likelihood of any pain, multiple pain and lower limb pain. One reason for this finding may be that unlike children with higher body fat content, lean children have no protective adipose tissue against painful injuries. Another explanation may be that in young children, a relatively short exposure to overweight has not yet overloaded the lower limbs long enough for associated pain complaints to develop. Although no relation between weight and the level of physical activity was found in the present study, weight status may play a modifying role in the relationship between physical activity and painful injuries; for example, an obese or overweight child may be prone to an increased risk of injury (Stovitz et al. 2008). However, on the contrary, Warsh et al. (2010) showed that BMI status did not have any significant effect on the relationship between physical activity and injuries.

There are no previously published reports on the associations of cardiorespiratory fitness (CRF) with various pain conditions in population samples of children 6–8 years of age. The results of the current study showed that children with high CRF had a lower risk of any pain and headache than children with low cardiorespiratory fitness. One explanation for the observation may be that children with higher CRF have better musculoskeletal health and thereby less muscle tension in the neck, shoulder and low back areas and, consequently, less musculoskeletal pain and headache than children with lower cardiorespiratory fitness. Good CRF might be linked with higher physical activity. Thus physical activity among children could enhance cardiorespiratory fitness on the one hand and reduce pain complaints on the other.

Surprisingly, in the present study, physical activity was not found to be associated with any pain conditions. However, the results of earlier studies on the associations of physical activity with pain conditions in children and adolescents have been inconsistent (Jones et al. 2003, Sollerhed et al. 2013, Wedderkopp et al. 2009). Physical activity was inversely associated with any pain in a study among children 8–12 years of age (Sollerhed et al. 2013). In another study, among children aged 9–12 years, higher physical activity levels were associated with a decreased risk of developing back pain (Wedderkopp et al. 2009). On the contrary, high levels of sports activity were related to an increased risk of having and developing widespread pain in children (Jones et al. 2003). High levels of physical activity were also associated with an increased risk of persistent musculoskeletal pain at multiple sites among adolescents (Pařízková and Hills 2005), but did not predict WSP in a 4-year follow-up study (Mikkelsson et al. 2008). One explanation for the inconsistent observations of the studies could be that moderate-to-vigorous exercise improves musculoskeletal fitness and health (Landry and Driscoll 2012), but some sports, such as ball games, may increase the risk of musculoskeletal injuries and consequent pains (Spinks et al. 2006). Furthermore, training that is too specific and monotonous as well as high training volume may enhance the occurrence of repetitive strain injuries (Arnold et al. 2017). In the present study, activity level or the activity itself were not specified, and therefore classifications due to intensity of the sports could not be made. One reason for not finding any association between physical activity and pain conditions in the present study may also be that the use of a physical activity questionnaire filled out by the parents reduced the likelihood of observing the relationship.

Restless sleep was associated with increased risk of orofacial pain and headache, but also with headache in the mornings. These results are consistent with the observation of other studies among children (Carra et al. 2012, Bellini et al. 2013). However, sleep duration or SDB were not related to craniofacial pains in the present study. One reason for this may be that only 10% of the children slept less than nine hours per night or had SDB (Ikävalko et al. 2012), and because of the low number of such children the possible relationships were not found in the statistical analyses. Headache has been reported to be approximately 3 times more common among children with sleep bruxism than among those without it (Carra et al. 2011). In the present study, it was found that sleep bruxism was related to increased risk of morning headache but not to headache in general. Studies that have reported the associations of sleep bruxism with morning headache have been conducted in adults (Rains et al. 2008, Lavigne and Palla 2010). Moreover, different causes such as obstructive sleep apnea, nocturnal desaturation, sleep efficiency, decrease in total sleep time or psychological symptoms such as depression have been associated with morning headache in adult population (Neau et al. 2002, Göder et al. 2003, Suzuki et al. 2015). As mentioned above, in the present study SDB did not associate with craniofacial pain, which included morning headache. Among children, bruxism has been associated with temporomanbibular joint sounds (Carlsson et al. 2002). In the current study, none of the clinical signs of TMD were related with sleep bruxism.

It has been shown that adolescents who skipped meals, especially breakfast, had headache more often than those who had regular eating habits (Moschiano et al. 2012). Moreover, fasting and skipping meals have been reported to trigger headache, and regular eating may therefore reduce its occurrence (Turner et al. 2014). In the present study, skipping meals was associated with increased risk for morning headache. The explanations for such an association are not yet clear and because of the cross-sectional nature of the study, the results do not expose any causal relationships between the two variables. One potential explanation is that the activity of the sympathetic nervous system increases due to prolonged fasting, which may result in headaches, particularly in the morning. On the other hand, headache in the mornings may also cause a lack of appetite and meal skipping. Another reason for the finding may be that skipping meals increases snacking, worsens diet quality, and causes fluctuation in plasma glucose levels and may thereby result in headaches.

In line with a previous study among 6- to 7-year old children (Bakoula et al. 2006), parental education did not associate with pain complaints in the present study. However, the findings of this study indicate that children in families with a low income were more likely to have morning headache than those with a high family income. This association did not remain after controlling for other confounding factors such as eating frequency, suggesting that a lower household income is associated with other predisposing factors for morning headache but is not an independent determinant of it. This finding is in line with previous studies suggesting that although lower socioeconomic position predisposes children to pain complaints, many other environmental, biological, and psychological factors related to the lower position may play a role in the etiology of the pain conditions (McGrath 2001, Kung et al. 2009).

An important observation of the present study was that children who reported back pain, headache, neck-shoulder pain or palpation tenderness in trapezius muscles were more likely to have clinical signs of TMD than those without such symptoms. The findings of the present study are in accordance with the results of earlier studies among adolescents and adults (Hagberg 1991, Sönmez 2001, List et al. 2001). However, no comparable previous studies in children were not found. Furthermore, it has been found that musculoskeletal pain in the neck and back was a strong predictor of WSP in adolescents 14–16 years of age (Mikkelsson et al. 2008). Also in the present study population, neck pain was one of the most common pain complaints, but since only 3% (14 children) had WSP, any connection between neck pain and WSP could not be addressed. The results of the present study suggest that more attention should be paid to neck-shoulder pain in childhood. Because clinical signs of TMD seem to appear already at a young age, routine dental examinations in children should include the evaluation of TMD and muscles in the neck-shoulder area should be palpated. This would help in the identification of children who need more careful follow-up of pain conditions and their consequences.

Crossbite or the use of occlusal appliance were not associated with TMD. Previous studies indicate a relatively weak association between the development of TMD and occlusal factors (DeBoever 2000, Taskaya-Yilmaz 2004). However, it is reasonable to suggest that some of them may demand greater adaptive responses in the function of the masticatory system. In a study on children and adolescents 5–17 years of age, skeletal anterior open bite, overjet greater than six to seven millimeters, class III malocclusion and posterior crossbite were found to be associated with TMD (Thilander et al. 2002). The reason for not finding any association between dental crossbite or the use of occlusal appliance and TMD signs or between the use of occlusal appliance and TMD in the present study may be that few of the children had crossbite and only 7% had an occlusal appliance.

6.4 IMPACT OF PAINS ON DAILY ACTIVITIES

Pain can interfere with a child´s daily living and reduce the quality of her/his life (Hunfeld et al. 2001, Scher et al. 2006) and be a burden for the child and the family (Perquin et al. 2000a, Clinch and Eccleston 2009). In the present study, more than half of the children reported restrictions in playing or pursuing other hobbies due to pain. In line with the present study, Roth-Isigkeit and co-workers (2005) found that in addition to loss of appetite and absence from school, sleep disturbances were the most prominent pain-related restrictions among children 4-9 years of age. Although school absence due to pain was not specifically evaluated, it was found in the present study that pain affected school activities in more than a third of the children. Another important finding was that pain was most prevalent in the evenings, mainly because of frequent lower limb pain, which probably represented growing pains. Two thirds of the children who reported pain in the evenings also reported disturbed sleep because of pain. In general, the time of the day when the pain occurs may be important when evaluating not only the outcomes but also the reasons for the pain.

The need of pain medication and the use of health care services vary according to the location and intensity of the pain and children's age (Walker et al. 1998, Roth-Isigkeit et al. 2005). Younger children use more health care services than older ones (Bruijnzeels et al. 1998). In the present study, pain medications had been used by 61% of the children with pain symptoms, especially those with lower limb pain, headache, neck-shoulder pain and abdominal pain. The proportion is higher than in a study where 52% of the children and adolescents used pain medication for their pain (Roth-Isigkeit et al. 2005). Moreover, 39% of those who reported chronic pain in a study among children and adolescents 0–18 years of age had used medication (Perquin et al. 2000b). One reason for the relatively high need for pain medication in the present study may be that acute and chronic pain were not separated; acute pain complaints may thus increase the need for pain medication at this age. In the current study, 16% of the children had visited a physician due to pain. The proportion is similar to the consultation rate of 15% in a Dutch study (Perquin et al. 2000a) and slightly higher than the 11% overall consultation rate, regardless of symptoms, in another study from the Netherlands (Bruijnzeels et al. 1998). In line with the current results, children with headache and lower limb pain visited a physician more often than those with other pain complaints (Bruijnzeels et al. 1998). The need for pain medication and health care services may be a burden for the child, the family or health care services, and therefore more attention should be paid to pain complaints in childhood.

6.5 STRENGTHS AND LIMITATIONS

A strength of the present study is that the PANIC Study as a whole is an extensive, controlled physical activity and diet intervention study in a representative population-based sample of prepubertal children. The participation rate at baseline was relatively high, 70%. Therefore, the results of this study are generalizable to the general population of Finnish primary school children. Based on the available school health examination data, the participating children did not differ in sex distribution, age and BMI-SDS from other children who started school in 2007–2009 in Kuopio. The non-participants were not asked for their reasons for non-participating. Therefore, a possibility of selection bias must be taken into consideration. The participating families may have been more motivated and interested in health-related issues and may have had healthier lifestyle habits than the non-participating families. This study had a cross-sectional design based on the baseline examinations alone, which hampers the interpretations of the results. The directions of the causality of the observed associations cannot be determined.

It is noteworthy that the PANIC Study as a whole is an extensive follow-up study with a large scale of assessments, including genetic factors (DNA isolated from blood samples and saliva samples). Although these possible confounding factors were not investigated in the current study, it would be interesting to determine the associations of these factors with pain findings in the future.

In the present study, pain was assessed by a questionnaire administered to the parents, similarly as in other epidemiological studies concerning pain in children (Aromaa et al. 2000, Roth-Isigkeit et al. 2005). Some studies suggest that parents may underestimate their children's pains (Brattberg 2004). In the present study, there were a number of children who could not read or write and therefore self-reporting was not possible. Therefore, the possibility of overestimation or underestimation of the pain symptoms cannot be excluded. Moreover, the parents reported their children's pain retrospectively, and the time covered a 3-month period before the examinations. The 3-month period for recalling pain in the present study is comparable to the periods used in earlier studies (Perquin et al. 2000a, Roth-Isigkeit et al. 2005). A limitation of the questionnaire is that it is difficult to separate chronic and acute pain. However, the intention in the present study was to examine the prevalence of pain conditions in young children in general and not even try to discriminate between chronic and acute pain. WSP was defined according to the set of screening criteria established by White and co-workers (White et al. 1999) which is commonly used among adults. At the moment of the children's base-line examination in the present study, no diagnostic criteria for WSP in children had been established (Mikkelsson et al. 2008). A weakness of the study may be that the pain questionnaire was not validated. An established questionnaire with piloting and validating would have enhanced the generalizability of the presented findings more reliably.

The Research Diagnostic Criteria for TMD (RDC/TMD) (Dworkin and LeResche 1992) was used to evaluate the signs of TMD. RDC/TMD has not been validated in children, but it has been used in other epidemiological and clinical studies and was the most widely used set of criteria for TMD. When an examination technique is adapted for children the degree of biological and intellectual maturity must be taken into consideration, and therefore Faces Pain Scale -Revised (Figure 4) was used to investigate the intensity of pain during examination. Clinical signs and symptoms of TMD were registered, but not the psychosocial factors in accordance to RDC/TMD. Thus, the children could not be classified under the TMD diagnosis. The PANIC Study included extensive clinical examinations and a considerable number of different questionnaires as well as food records. Because of this, the whole RDC/TMD questionnaire could not be included in the present study. However, it would have been interesting to determine psychosocial factors according to RDC/TMD associated with the clinical signs and symptoms of TMD as compared with other pain findings. However, the psychological well-being, which was assessed, did not associate with painful signs of TMD.

The newly recommended Diagnostic Criteria for TMD (DC/TMD) (Schiffman et al. 2014) are appropriate for use both in research and clinical settings, and they are now replacing RDC/TMD but were not available when the present study was launched.

Sedentary behavior and physical activity were assessed by a questionnaire filled out by parents. The validity of the questionnaire measuring the time spent in physical activity was tested against the Actiheart monitor combining heart rate and accelerometry measurements (Actiheart, CamNtech, Cambridge, UK) in a subsample of 38 children (Väistö et al. 2014). Total physical activity measured by the questionnaire correlated with that measured by the Actiheart monitor (correlation coefficient r 0.37, $p = 0.033$). However, the measure error due to self-report may still be large and must be considered as a limitation of the study because some parents may have systematically over- or underestimated their children's sedentary behavior and physical activity.

Body mass index – standard deviation score (BMI-SDS) was calculated with comprehensive Finnish references (Saari et al. 2011). Body adiposity was measured directly by the DXA method, which is considered to be the most reliable way of assessing body adiposity in children (Helba and Binkovitz 2009). The use of body fat percentage as a continuous variable in the analyses enabled the detection of associations that are linear in nature. Cardiorespiratory fitness was assessed using maximal cycle ergometer exercise test, which is suitable for children (Kantomaa et al. 2011). Lifestyle variable scores were divided into equally sized thirds based on distribution of each variable; no predetermined cut-off values were used. The sex-specific thirds of sedentary behavior, physical activity, cardiorespiratory fitness and body fat percentage were used in the analyses to take into account the different distributions of the lifestyle-related factors in girls and boys and to be able to analyze the dose-response relationships of those factors with pain conditions.

The sleep questionnaire was based on an established Finnish questionnaire which has been used to screen for sleep disturbances and SDB (Partinen and Gislason 1995) and was modified in the present study for the parents to fill out on behalf of their children. Sleep quality and signs of SDB or sleep bruxism were assessed by the questionnaire. Some parents may have been unaware of their child´s sleep pattern as well as mode of breathing due to sleeping in a different room than the child. Moreover, when assessing sleep bruxism, a clinical examination and other more exact diagnostic methods (as listed by Lobbezzoo et al. 2013) could not be performed due to the type of the present study. Furthermore, there was no opportunity to conduct demanding polysomnographic examinations to expose sleep disorders; instead, they were assessed by questionnaires filled out by the parents because of the large study sample of mainly healthy children. Duration of sleep was assessed by the combined heart rate and movement sensor, Actiheart, which is accurate and suitable for the purpose.

A wide range of possible confounding factors was measured. Comprehensive and valid assessments of dental malocclusions, the use of occlusal appliance, maturity and parental socioeconomic status were used. In the present study, dietary factors were assessed by food records over four consecutive predefined days and questionnaires completed by the parents. A clinical nutritionist instructed the parents to fill out the food records and reviewed them upon return. Although self-reported records are often prone to biases, careful work in instructing, reviewing and analyzing the records diminishes the misreporting error. Eating frequency was calculated using food records. Each eating occasion was defined as breakfast, lunch, dinner or snack based on the recorded time and the type of food by the impressions of the clinical nutritionist. This approach was used because there are no feasible, standardized and objective criteria for defining meals and snacks in children. A weakness of the study may be that no specific and validated measures of psychological factors such as anxiety and depression were used; instead, overall psychological well-being on 19 items was assessed with a questionnaire. However, it would be difficult to study the validity of a questionnaire on psychological well-being in a population sample of children because there is no "gold standard" for the purpose.

7 Conclusions and future perspective

In conclusion, according to the present results, reported bodily pain complaints and clinical signs of TMD are common among children 6-8 years of age.

Because it was found that low cardiorespiratory fitness and high levels of sedentary behavior were associated with increased likelihood of various pain conditions among young children, more attention should be paid to daily activities, encouraging children to be more physically active. Thus, these relationships suggest that children who have higher cardiorespiratory fitness and who avoid sitting have better musculoskeletal health. Furthermore, the association between body fat content and pain conditions suggests that lean children are more prone to pain complaints. It may be that abundant adipose tissue protects against painful musculoskeletal injuries in overweight and obese children. However, overweight or obesity may have a significant impact on the health and well-being of children and may contribute to ongoing health problems such as musculoskeletal pain and bone/joint dysfunction in later life (MacFarlane et al. 2011).

Irregular eating frequency, restless sleep and sleep bruxism were associated with morning headache. These findings are useful in identifying children at increased risk for developing headache in the mornings. Particularly, the accumulation of several life-style related factors behind headaches seems to decreased the quality of life (Perquin et al. 2000a).

The risk of clinical signs of TMD was significantly higher among children who had some other pains, such as headache, neck-shoulder pain, or back pain. There was a relationship between neck-shoulder muscle palpation tenderness and clinical signs of TMD. These relationships suggest that more attention should be paid to neck-shoulder pain and the prevention of these pains in childhood. Because clinical signs of TMD seem to appear already at a young age, routine dental examinations in children should include the evaluation of TMD.

The results suggest that modification of lifestyle habits could be significant in the prevention strategies of pain complaints and TMD, especially in childhood. In the future, longitudinal population-based studies are needed. Thus, future research should seek deeper knowledge and understanding in this area. Early intervention may prevent the progression of pain complaints in childhood into chronic pain later on in adolescence and adulthood.

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ANU VIEROLA

The aim of this doctoral thesis was to investigate the prevalence and determinants of pain complaints and temporomandibular disorders (TMD) in a population sample of children 6-8 years of age from the Physical Activity and Nutrition in Children (PANIC) Study. The results showed that high levels of sedentary behavior and low cardiorespiratory fitness were associated with pain complaints. Restless sleep, skipping meals and sleep bruxism were related to increased likelihood of headache. Back pain, headache and palpation tenderness in neck-shoulder muscles were related to increased risk for TMD.

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PUBLICATIONS OF
THE UNIVERSITY OF EASTERN FINLAND
Dissertations in Health Sciences

ISBN 978-952-61-2669-2
ISSN 1798-5706