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Temporomandibular disorders – prevalence of symptoms and association with health behaviors and oral health-related quality of life

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Academic dissertation to be presented with the assent of the Doctoral Programme Committee of Health and Biosciences of the University of Oulu for public defence in the Markku Larmas auditorium (H1091) in Dentopolis, on 18 August at 12 noon.

University of Oulu, Oulu 2023

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ISBN 978-952-94-8068-5 (Paperback)
ISBN 978-952-94-8069-2 (Online)

Cover design
Ossi Miettinen

Punamusta
Joensuu 2023

Miettinen, Ossi, Temporomandibular disorders – prevalence of symptoms and association with health behaviors and oral health-related quality of life
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Abstract

The aim of this study was to investigate the prevalence of symptoms of temporomandibular disorders (TMD) and their association with health behaviors, i.e., smoking habits, alcohol consumption, physical activity and physical fitness, and obesity among Finnish conscripts. Another aim was to investigate the association between the psychosocial aspects of TMD and oral health-related quality of life (OHRQoL)in patients with TMD.

A total of 13 819 conscripts answered a computer-based questionnaire on TMD symptoms and health behavior. Further, physical fitness tests were performed and body mass index (BMI) was measured. The psychosocial aspects of TMD and OHRQoL were investigated in a sample of 79 TMD patients and 70 dental students. OHRQoL was assessed with Oral Health Impact Profile (OHIP-14). The psychosocial factors were inquired based on the Finnish translation of the RDC/TMD Axis II instruments.

Among conscripts, the prevalence of self-reported TMD symptoms varied between 5.8% and 27.8%. The most significant health behavior factors associating with TMD symptoms were heavy smoking and frequent regular consumption of alcohol. Poor physical fitness, low physical activity, and high BMI associated significantly with pain-related TMD symptoms. TMD patients had significantly poorer OHRQoL than non-patients. Psychosocial risk factors, i.e., pain-related disability, depression and somatization symptoms, associated with OHRQoL among both genders.

In conclusion, the prevalence of TMD symptoms is relatively high among generally healthy young adults. In prevention and treatment of TMD, decreasing the use of psychoactive substances and increasing physical fitness and activity should also be considered. In addition, TMD associates with OHRQoL by multiple ways, especially through psychosocial factors. These factors should be evaluated and considered in the treatment of TMD.

Keywords: alcohol, BMI, temporomandibular disorders, Oral Health Impact Profile, oral health-related quality-of-life, physical fitness, physical activity, prevalence, psychosocial factors, smoking.

Miettinen, Ossi, Purentaelimistön toimintahäiriöt – oireiden esiintyvyys ja yhteys terveyskäyttäytymiseen sekä suun terveyteen liittyvään elämänlaatuun
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Tiivistelmä

Tutkimuksen tavoitteena oli selvittää purentaelimistön toimintahäiriöiden (temporomandibular disorders, TMD) oireiden prevalenssia ja niiden yhteyttä terveyskäyttäytymiseen, kuten tupakointiin, alkoholin käyttöön, fyysiseen aktiivisuuteen ja lihas- ja kestävyyskuntoon sekä ylipainoon suomalaisilla varusmiehillä. Tutkimuksen toisena tavoitteena oli tutkia purentaelimistön toimintahäiriöiden psykososiaalisten tekijöiden yhteyttä suun terveyteen liittyvään elämänlaatuun TMD-potilailla.

Kaikkiaan 13 819 varusmiestä vastasi tietokonepohjaiseen kyselyyn TMD-oireista sekä terveyskäyttäytymisestä. Lisäksi tehtiin fyysiset kuntotestit ja mitattiin painoindeksi. Purentaelimistön toimintahäiriöiden psykososiaalisia tekijöitä ja suunterveyteen liittyvää elämänlaatua tutkittiin otoksella käsittäen 79 TMD-potilasta sekä 70 opiskelijaa kontrolleina. Suun terveyteen liittyvää elämänlaatua arvioitiin Oral Health Impact Profile (OHIP-14) -kyselyllä. Psykososiaalisia tekijöitä arvioitiin suomenkielisillä Research Diagnostic Criteria for TMD (RDC/TMD) Axis II-instrumenteilla.

Itseraportoitujen TMD-oireiden prevalenssi varusmiehillä vaihteli 5,8 %:n ja 27,8 %:n välillä. TMD- oireisiin liittyvät merkittävimmät terveyskäyttäytymiseen liittyvät tekijät olivat runsas tupakointi ja toistuva säännöllinen alkoholin käyttö. Huono lihas- ja kestävyyskunto, vähäinen fyysinen aktiivisuus ja korkea painoindeksi olivat merkitsevästi yhteydessä TMD- kipuoireisiin. TMD- potilailla oli merkitsevästi huonompi suun terveyteen liittyvä elämänlaatu kuin verrokkiryhmällä. Psykososiaaliset riskitekijät, kuten kipuun liittyvä toimintahaitta, masennus- ja somatisaatio-oireet olivat yhteydessä suun terveyteen liittyvään elämänlaatuun molemmilla sukupuolilla.

Tutkimuksen perusteella voidaan päätellä, että TMD- oireiden prevalenssi on suhteellisen korkea terveillä nuorilla aikuisilla. TMD:n ehkäisyssä ja hoidossa tulisi myös pyrkiä vähentämään psykoaktiivisten aineiden käyttöä ja panostaa kuntoa kasvattavaan liikuntaan ja liikkumiseen. Lisäksi TMD on yhteydessä suun terveyteen liittyvään elämänlaatuun monin eri tavoin, erityisesti psykososiaalisten tekijöiden kautta. Nämä tekijät tulisi arvioida ja ottaa huomioon TMD:n hoidossa.

Avainsanat: alkoholi, fyysinen kunto, fyysinen aktiivisuus, Oral Health Impact Profile, painoindeksi, prevalenssi, psykososiaaliset tekijät, purentaelimistön toimintahäiriöt, suun terveyteen liittyvä elämänlaatu, tupakointi

To Auli, Liisi and Kaarlo

Acknowledgements

This study was carried out at the Research Unit of Oral Health Sciences, University of Oulu, and the University of Eastern Finland, Kuopio, Finland, in collaboration with the Finnish Defence Forces' Centre for Military Medicine during the years 2010–2022.

My sincerest appreciation goes to my mentors, Professor Kirsi Sipilä, DDS, PhD, Professor Vuokko Anttonen, DDS, PhD, and Docent Antti Kämppi, DDS, PhD, for their invaluable guidance and unwavering support throughout this fascinating, educational, and at times challenging research endeavor.

Kirsi, I would like to express my deepest and most special thanks to you. You have played the most significant role in the completion of this dissertation, as well as in my clinical work while specializing as a specialist dentist. You have also been instrumental during my life-changing move to Kuopio. This journey has brought about brilliant turns and new opportunities in my life, for which I am truly grateful.

My special thanks are expressed to Commander Pertti Patinen, DDS, PhD, from the Finnish Defence Forces' Centre for Military Medicine for his collaboration, comments, and encouragement throughout the course of this work. I express my appreciation to my co-authors, Professor Satu "Mama" Lahti, DDS, PhD, Professor Leo Tjäderhane, DDS, PhD, and Docent Tarja Tanner, DDS, PhD. Your collaboration, guidance, and expertise have been invaluable. I am grateful for the time and effort you have dedicated to our joint publications, as well as for the knowledge and experience you have generously shared. Your constructive feedback, attention to detail, and unwavering support have played a significant role in the development and completion of this work.

Collaboration is invaluable, and my heartfelt appreciation is also expressed to Jari Päkkilä, MSc, for his patient assistance in navigating the numerous statistical challenges I faced. His unwavering dedication to addressing my myriad inquiries about SPSS and statistics was truly commendable.

I also express my gratitude to the pre-examiners of this dissertation, Professor Murat Mutluay, DDS, PhD, and Professor Tommi Vasankari, MD, PhD. Your expertise, constructive feedback, and invaluable insights have significantly contributed to the quality and rigor of my research. I acknowledge Anna Vuolteenaho, FM, who revised the language of the journal articles and this thesis.

I express my gratitude to all my friends and colleagues who have supported me throughout the course of this dissertation. Your camaraderie, encouragement, and understanding have been essential in helping me to navigate in the ups and downs of this journey. My special thanks are extended to my colleagues and dear friends, especially to Miika, Ville, and Antti. Your invaluable advice, constructive feedback, and unwavering support have not only enriched my research but have also made this experience more enjoyable and fulfilling. I am truly grateful for each one of you, and I feel fortunate to have the opportunity to work alongside such dedicated and talented individuals. Thank you for being a crucial part of my academic and personal growth.

My heartfelt appreciation is extended to my parents, Seija and Juha, who have always been there for me throughout my life and academic journey. Your unwavering belief in my abilities, constant encouragement, and invaluable guidance have shaped me into the person I am today. You have instilled in me the importance of hard work and perseverance, qualities that have been critical to the success of this dissertation. My heartfelt thanks are also extended to my siblings for their understanding, companionship, and encouragement throughout this journey. I wish to express my deepest appreciation to my idol and mentor, grandfather Ahti. Thank you for being a beacon of inspiration and a true role model in my life.

Finally, my deepest gratitude goes to my family, who have been my unwavering support throughout this journey. To my wife, Auli, your love and encouragement have been the driving force behind my success. Your patience and understanding have made it possible for me to focus on my research and complete this thesis. To my children, Liisi and Kaarlo, you are my greatest source of inspiration and motivation. Thank you all for standing by my side and for believing in me, even when the journey seemed insurmountable. I dedicate this work to you.

Kuopio, March 2023 *Ossi Miettinen*

Abbreviations

BMI	Body Mass Index
CI	Confidence Interval
GCPS	Graded Chronic Pain Scale
RDC/TMD	Research Diagnostic Criteria for Temporomandibular Disorders
DC/TMD	Diagnostic Criteria for Temporomandibular Disorders
OPPERA	Orofacial Pain Prospective Evaluation and Risk Assessment
OHIP	Oral Health Impact Profile
OHRQoL	Oral Health-Related Quality of Life
OR	Odds Ratio
PANIC	Physical Activity and Nutrition in Children
SCL-90-R	Symptom Checklist-90-Revised
TMJ	Temporomandibular Joint
TMD	Temporomandibular Disorders
WHO	World Health Organization

List of the original publications

This thesis is based on the following publications, which are referred to throughout the text by their Roman numerals:

I Miettinen, O., Anttonen, V., Patinen, P., Päkkilä, J., Tjäderhane, L., & Sipilä, K. (2017). Prevalence of Temporomandibular Disorder Symptoms and Their Association with Alcohol and Smoking Habits. *Journal of Oral & Facial Pain and Headache, 31*(31), 30–36. https://doi.org/10.11607/ofph.1595

II Miettinen, O., Kämppi, A., Tanner, T., Anttonen, V., Patinen, P., Päkkilä, J., Tjäderhane, L., & Sipilä, K. (2021). Association of Temporomandibular Disorder Symptoms with Physical Fitness among Finnish Conscripts. *International Journal of Environmental Research and Public Health, 18*(6), 3032. https://doi.org/10.3390/ijerph18063032

III Miettinen, O., Lahti, S., & Sipilä, K. (2012). Psychosocial aspects of temporomandibular disorders and oral health-related quality-of-life. *Acta Odontologica Scandinavica, 70*(4), 331–336. https://doi.org/10.3109/00016357.2011.654241

Contents

1 Introduction

Temporomandibular disorders (TMD) are pain disorders and dysfunctions of the temporomandibular joints (TMJs) and the masticatory muscles, dentition, and closely related structures (Okeson, 2019). The most common TMD signs and symptoms are TMJ sounds (clicking and crepitation), pain in masticatory muscles and/or TMJs, and limitations and deviations in jaw movements.

The prevalence of TMD varies between the studies due to the use of different criteria and methods for defining TMD signs and symptoms. According to the previous studies, 30–90% of the population report at least one clinical TMD sign, and 15–50% of the population report at least one symptom associated with TMD (Jussila, 2017; Rutkiewicz, 2006). In addition, TMD signs and symptoms are quite common among young adults and adolescents, with prevalence varying from 7 to 34% (Christidis, 2019; Qvintus, 2020). TMD are more frequent among women than men, being twice as common than in the general population, and in a TMD patient population the proportion of women is fourfold compared to the proportion of men (Dworkin, 1990; LeResche, 1997). The prevalence of TMD symptoms seems to be the highest among those 35–50 years of age (Al-Jundi et al., 2008; Kuttila et al., 1998; Köhler et al., 2012; Lövgren et al., 2016).

The etiology of TMD is multifactorial and complex: the onset and prognosis of TMD symptoms are influenced by many physiological, psychosocial, and behavioral factors. Psychosocial risk factors such as distress, depression, and non-specific physical symptoms are associated with pain-related TMD (Maixner et al., 2016; Sipilä et al., 2013; Smith et al., 2009).

Among Finnish adolescents, the use of tobacco products (smoking and use of snuff) has long been declining, but over the past few years the decreasing trend has stopped. Smoking is still common among young adult population in Finland: 17% of 18-year-old males and 14% of females smoked daily according to the Finnish Adolescent Health and lifestyle Survey in 2019 (Kinnunen et al., 2019). On the other hand, the use of snuff is on the rise. The decline in alcohol consumption among young Finnish adults has also stopped; 24% of 18-year-old males and 17% of females used alcohol at least once a week. The role of health behaviors and lifestyle factors related to TMD and chronic pain have been investigated (Benoliel et al., 2011; Johansson et al., 2004; Slade et al., 2013), but there are very few studies about the use of psychoactive substances in association with TMD (de Leeuw et al., 2013; Melis et al., 2010; Rintakoski et al., 2013; Sanders et al., 2012; Wänman, 2005). Studies have shown that smokers with TMD report higher pain severity than non-smokers (de Leeuw et al., 2013; Melis et al., 2010), and smoking is associated with an increased risk for TMD in young adulthood. Alcohol consumption and smoking and their associations with TMD symptoms have mostly been studied in clinical studies with TMD patients (de Leeuw et al., 2013; Sanders et al., 2012; Wänman, 2005). To date, strong evidence for an association between smoking and alcohol consumption and TMD has not been established.

Studies concerning the role of physical activity, physical fitness, and body mass index (BMI) in TMD are scarce. Endurance of physical strain in patients with TMD has been studied by Wänman (Wänman, 2011), showing that TMD patients have an impaired capacity to endure physically demanding tasks that specifically involve the jaw and shoulder girdle muscles. TMD have been classified as a musculoskeletal disorder and they have been shown to have similar risk factors (Vierola et al., 2016). Physical activity and fitness have been found to be associated with musculoskeletal pain, very active participation in physical activities, and on another hand, a large amount of sitting is related to low back pain (Auvinen et al., 2007).

TMD may have several consequences, including impaired Oral Health-Related Quality of Life (OHRQoL), which includes subjectively evaluated physical, psychosocial and social aspects of oral health (Locker & Allen, 2007). Studies have shown a negative impact on OHRQoL in patients with TMD (Bayat et al., 2018; Yap et al., 2021), particularly in patients with psychological impairments (Oghli et al., 2020). Nonetheless, the number of studies concerning TMD and OHRQoL is relatively low, and further studies are needed to evaluate the level of impaired OHRQoL in TMD and for investigating the psychosocial aspects in this association.

Conscripts make up a special population of mainly young men. Finnish conscripts form an ideal study population for cross-sectional studies; representing the vast majority of any male age cohort, the conscript population offers a good opportunity to investigate the association of lifestyle factors with the presence of TMD symptoms.

The main aim of this study was to investigate the prevalence of TMD and its association with health behaviors among Finnish conscripts. The health behavior factors that were specifically studied were smoking habits, alcohol consumption, physical activity and physical fitness; in addition, the role of obesity in TMD was also a focus of interest. The study also aimed to evaluate the association between the psychosocial aspects of TMD and OHRQoL in a sample of TMD patients.

2 Review of literature

2.1 Temporomandibular disorders (TMD)

2.1.1 Definition, symptoms, and signs of TMD

Temporomandibular disorders (TMD) is a collective term for pain conditions and disorders of the temporomandibular joints (TMJ), masticatory muscles, dentition, and closely related tissues (Okeson, 2019). TMD are considered a chronic pain condition and belong to musculoskeletal pain conditions.

Several symptoms and signs are linked with TMD. A symptom is self-estimated by a patient and not included in the examination. TMD symptoms can be divided into specific and non-specific symptoms. A sign is an objective clinical finding based on clinical examination (de Leeuw & Klasser, 2018; Okeson, 2019).

TMD is a common cause of facial pain, and facial pain is the most common cause for seeking treatment in TMD patients. In addition to pain, specific TMD symptoms are TMJ sounds (clicking, popping and crepitus), jaw fatigue and stiffness, and limitation in the range of mouth opening or other lower jaw movements. The following features are typical of TMD pain: the pain is localized in the face, jaws, temporal area and ears on either side or both sides, the pain is usually described as dull, drowsy and disturbing, the pain has symptomatic variation, and chewing or other jaw functions change the symptoms. There are also several non-specific TMD symptoms that can appear in connection with TMD, or they may also be related to other diseases besides TMD. The non-specific TMD symptoms are pain and foreign sensation (e.g., numbness) in the jaw, face and head area, ear symptoms such as ear pain, tinnitus and congestion, throat symptoms such as a feeling of burning in the throat and difficulty swallowing, problems with the use of sound, such as hoarseness and losing voice, neck and shoulder pain, and dizziness (de Leeuw & Klasser, 2018; Okeson, 2019; Schiffman et al., 2014).

The most common clinical signs of TMD are TMJ sounds (clicking or crepitation), muscle pain or TMJ pain on jaw movement or palpation, and limitations and pain on jaw movements (Okeson, 2019).

2.1.2 Prevalence

The prevalence of TMD signs and symptoms is common in the population. The prevalence levels in different epidemiological studies vary widely, depending on the study sample, study design and the criteria for TMD (Carlsson et al., 1999). In most studies, the prevalence of single symptoms has been 15–50% (Huhtela et al., 2016; Jussila et al., 2017; Köhler et al., 2012, Kunttu et al., 2016; Lövgren et al., 2016; Qvintus et al., 2020; Yekkalam & Wänman, 2014) and the prevalence of clinical signs 40–90% in the adult population (Carlsson et al., 1999; Jussila et al., 2017; Qvintus et al., 2020; Rutkiewicz et al., 2006).

Several studies have shown gender differences in the prevalence of TMD. Compared to men, women have more symptoms (Jussila et al., 2017; Qvintus et al., 2020; Yekkalam & Wänman, 2014), signs (Jussila et al., 2017; Rutkiewicz et al., 2006) and clinically diagnosed TMD (Bueno et al., 2018; Jussila et al., 2017). Furthermore, approximately 80% of TMD patients are women (LeResche, 1997). In addition, TMD pain is more common among girls than boys (Ivkovic et al., 2018; List et al., 1999; Nilsson et al., 2005; Ribeiro-Dasilva et al., 2017; Tashiro & Bereiter, 2020; Wahlund, 2003). Based on the Orofacial Pain Prospective Evaluation and Risk Assessment (OPPERA) study (Maixner et al., 2011; Slade et al., 2016), the incidence of developing TMD has been reported to be approximately 4–6.5% (Slade et al., 2016; Von Korff et al., 1993).

Symptoms of TMD are most common at the age of 35–50 years (Al-Jundi et al., 2008; Kuttila et al., 1998; Köhler et al., 2012; Lövgren et al., 2016). They are also frequent in young adults. In student population, the prevalence of TMD symptoms has been reported at 41% (Huhtela et al., 2016). TMD symptoms are rare in children aged 3 to 5 years (Köhler et al., 2009). Based on the Finnish PANIC (Physical Activity and Nutrition in Children) study, symptoms of TMD are reported by 26% of children aged 6 to 8 years and clinical findings are seen in 14% of children (Vierola et al., 2017). In school-age children, TMD symptoms and findings are relatively common (35–62%) but are usually mild and intermittent, whereas more severe symptoms are found in approximately 5–9% of 10- to 15-year-olds and are often associated with systemic diseases such as juvenile rheumatoid arthritis (Köhler et al., 2009; Könönen et al., 1996; List et al., 1999; Stoll et al., 2012). Symptoms of TMD appear to decrease at the age 70 years, although more clinical findings may be observed (Hiltunen et al., 2003; Köhler et al., 2012; Osterberg & Carlsson, 2007; Qvintus et al., 2020; Yekkalam & Wänman, 2014).

2.2 Factors associated with TMD

2.2.1 General factors

The etiology of TMD is multifactorial and complex: the onset and prognosis of TMD symptoms are influenced by many physiological, psychosocial and behavioral factors. These factors can predispose to, trigger, or maintain symptoms of TMD (Maixner et al., 2011). Biopsychosocial, genetic, and environmental factors may influence the onset and persistence of TMD. Based on the OPPERA study, various sociodemographic and clinical orofacial characteristics, general health status and health care behaviors predict the development of TMD (Bair et al., 2016; Maixner et al., 2011; Ohrbach et al., 2013; Slade et al., 2013).

Several other factors such as female gender, other pain conditions, musculoskeletal and systemic connective tissue diseases, general joint hypermobility, sleep problems, traumas, smoking, and psychological and psychosocial factors such as anxiety, depression, stress, non-specific physical symptoms and catastrophizing, may predict the onset and chronification of TMD. Furthermore, distinct occlusal factors and bruxism may associate with TMD (Okeson, 2019).

Recently, the role of health behavior and lifestyle factors, such as smoking, has been the focus of TMD research (Sanders et al., 2013). TMD symptoms can be compared to other musculoskeletal problems in the body, and prolonged TMD pain has been shown to be a similar problem to other chronic pain problems (Chen et al., 2013; Dworkin, 1995; Suvinen et al., 2005).

2.2.2 Psychosocial factors

The general consensus is that psychological and psychosocial factors are very important in the background of TMD. Psychosocial factors have a multifactorial relationship with TMD; they can be both the cause and the consequence of chronic pain and they increase the risk for chronification (Baune et al., 2008; Dohrenwend et al., 1999; Magni et al., 1994; Sanders et al., 2013; Suvinen et al., 2005).

Based on several cross-sectional studies, psychosocial risk factors such as distress, depression, and non-specific physical symptoms are often linked with pain related to TMD (Maixner et al., 2016; Sipilä et al., 2013; Smith et al., 2009). Furthermore, depression and non-specific physical symptoms are more common among patients with TMD than among those who do not suffer from TMD (Hirsch

& Türp, 2010; Suvinen et al., 2005). These associations have been shown in both population-based (Huhtela et al., 2021; Maixner et al., 2016; Sipilä, 2001; Smith et al., 2009; Tuuliainen et al., 2015) and patient (Hietaharju et al., 2021; Hirsch & Türp, 2010; Yap et al., 2021) samples.

Other psychosocial risk factors include sleep problems, stress, catastrophizing, anxiety, and other pain conditions. In the prospective OPPERA study, factors that increased the risk for chronic pain included stress, catastrophizing, other somatic symptoms and stress (Bair et al., 2013; Fillingim et al., 2013; Greenspam et al., 2013).

2.2.3 Use of psycho-active substances

Smoking

Lately, the role of health behavior, lifestyle and general health impairing factors related to chronic pain and TMD has been investigated (Benoliel et al., 2011; Johansson et al., 2004; Slade et al., 2013). There are only few studies concerning the association between smoking and TMD (de Leeuw et al., 2013; Melis et al., 2010; Sanders et al., 2012; Wänman 2005). Melis et al. (2010) found that smokers with TMD reported higher pain severity than non-smokers. Based on the OPPERA study, Sanders et al. (2012) found that smoking was associated with TMD risk in females in young adulthood. In a study conducted on 3 251 TMD patients, smokers reported significantly higher pain severity, impairment, anxiety, depression, and sleep disturbances than nonsmokers (de Leeuw et al., 2013). Similarly, another study (Custodio et al., 2021) found that among patients with masticatory myalgia, smokers reported higher pain severity and more sleep disturbances and psychological distress than nonsmokers.

A study by Benoliel et al. (2011) on medical students found that those with painful TMD had higher depression scores and smoked more tobacco than those without TMD. In addition, of the variables associated with TMD symptoms, bruxism has been reported to associate with heavy tobacco use (Rintakoski, Ahlberg, Hublin, Lobbezoo et al., 2010).

Alcohol

There have been only few studies concerning the association between TMD and alcohol consumption (Macfarlane et al., 2014; Rintakoski & Kaprio, 2012; Selaimen et al., 2006). Based on a study on muscle-related TMD patients, Selaimen et al. (2006) found that a combination of three TMD lifestyle predictors (i.e., sleep, smoking and alcohol) had better predictive value than analyzing them individually. Rintakoski & Kaprio (2012), based on the Finnish Twin Cohort study (n = 12 502), found that increasing alcohol intake raised the risk for weekly bruxism. Based on cross-sectional population data obtained from a UK Biobank (n = appr. 500 000), Macfarlane et al. (2014) found that smoking associated with increased report of facial pain while alcohol consumption had a protective effect on facial pain as compared to never drinkers.

As the number of studies on the association between consumption of psychoactive substances and TMD is low, further population-based studies are needed to investigate its role.

2.2.4 Physical activity and fitness

Studies concerning the role of physical fitness and physical activity on TMD are still scarce. Nonetheless, there are some studies concerning chronic pain and physical fitness (Auvinen et al., 2007; Vierola et al., 2016; Wänman, 2011). As TMD have been classified as musculoskeletal disorders, the risk factors have been shown to be similar.

In the cross-sectional PANIC study on prepubertal children, Vierola et al. (2016) found that high levels of sedentary behavior, low levels of cardiorespiratory fitness, and low body fat content increased the likelihood of pain conditions, whereas physical activity was not associated with pain conditions. In the Northern Finland Birth Cohort 1966 (n = 5 999), Auvinen et al. (2007) investigated the associations of physical activity and inactivity with low back pain in adolescents at the age of 15–16 years. They found that a high amount of sitting in girls and very active participation in physical activities in both girls and boys were related to self-reported low back pain. However, that study did not study TMD-related pain.

Wänman (2011) investigated endurance of physical tasks in TMD patients in a case-control study. TMD patients had statistically significantly lower endurance than controls in all tests. These tests were specifically focused on the jaw and shoulder girdle muscles.

The role of physical activity on TMD and chronic pain in general has shown partly controversial results as shown in studies by Vierola et al. (2016) and Wänman (2011). Based on a recent population study on South Korean population (16 941 participants), moderate or intense physical activity was found to be associated with more TMD pain (Cho et al., 2020). However, more reasearch is needed on the TMD association with physical fitness and activity due to limited number of studies.

2.3 Diagnostics of TMD

Diagnosis of TMD is based on self-report of symptoms and clinical examination. When needed, imaging methods, such as cone beam CT (CBCT) and magnetic resonance imaging (MRI) are performed. The status of occlusion is one of the most important parts of the clinical examination of a TMD patient. The status of the occlusion, possible malocclusions, interferences in the centric occlusion and jaw movements (lateral and protrusive) are registered. If necessary, further examinations may include, e.g., sensory and provocation examinations, cervical structure examination and pharmacological tests (Okeson, 2019).

There have been several different diagnostic systems and criteria for TMD during the past decades. Helkimo's anamnestic and clinical dysfunction indices (Helkimo, 1974) were developed mainly for epidemiological purposes. In addition, the questions by Nilsson et al. (2006) have been shown to be valid for screening of TMD-related pain (Lövgren et al., 2018; Nilsson et al., 2006).

For more comprehensive diagnostics, the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD), and later, the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) have been developed.

2.3.1 The Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD)

The Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) were developed in 1992 (Dworkin & LeResche, 1992). The RDC/TMD have been used worldwide and have been translated to 21 languages by clinical experts. The RDC/TMD include a dual axis, of which Axis I provides the clinical diagnoses, based on symptoms and clinical signs, and Axis II assesses the psychosocial risk factors.

The clinical Axis I diagnoses include the following: muscle diagnoses (myofascial pain, myofascial pain with limited opening), disc displacement (disc displacement with reduction, disc displacement without reduction with limited opening, disc displacement without reduction without limited opening), arthralgia, arthritis and arthrosis (arthralgia, osteoarthritis of the TMD, osteoarthrosis of the TMJ).

Axis II evaluates the psychosocial symptoms and pain-related disability, containing the subscales of graded chronic pain scale (GCPS), depression and non-specific physical symptoms. The pain-related disability is evaluated by the GCPS 1.0 questionnaire (Von Korff et al., 1992), and the symptoms of depression and non-specific physical symptoms are evaluated using Symptom Checklist-90-Revised (SCL-90R) (Derogatis, 1994; Dworkin & LeResche, 1992; Von Korff et al., 1992). The non-specific physical symptoms reported in SCL-90R are complaints of cardiovascular, gastrointestinal, respiratory, and other autonomic systems, reflecting distress sensed with bodily perceptions (Dworkin & LeResche, 1992). The RDC/TMD Axis I protocol for clinical diagnostics has been shown to be valid (Schiffman et al., 2010). Also, the GCPS 1.0 and other Axis II psychosocial instruments (depression and non-specific physical symptoms) have shown to be reliable and valid (Anderson et al., 2010; Schiffman et al., 2010). However, the RDC/TMD Axis I Validation Project reported that RDC/TMD Axis I validity was below the target (sensitivity ≥ 0.70 and specificity ≥ 0.95) (Schiffman et al., 2014).

The RDC/TMD was developed mainly for research purposes, whereas it is quite complex to use in clinical practice. Because of this and in order to improve the validity, the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) protocol were developed (Dworkin et al., 2002; Schiffman et al., 2014). The DC/TMD is shorter and simpler than the RDC/TMD for both clinical practice use and research purposes.

2.3.2 The Diagnostic Criteria for Temporomandibular Disorders (DC/TMD)

The Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) were developed and published in 2014 for use in both clinical and research settings (Schiffman et al., 2014). The DC/TMD includes Axis I and Axis II sections as well as the RDC/TMD.

The DC/TMD Axis I includes different instruments: DC/TMD Pain Screener for screening TMD-related pain, DC/TMD Symptom Questionnaire including questions about TMD symptoms, and a protocol and instructions for a clinical examination and for assessing clinical findings for a proper diagnosis. The DC/TMD symptom questionnaire assesses familiar pain (pain the patient has felt during the previous 30 days), referred pain, and TMD-related headache (Schiffman et al., 2014), among others.

The DC/TMD Axis I protocol includes valid diagnostic criteria for differentiating the most common pain-related TMD diagnoses (sensitivity ≥ 0.86 and specificity ≥ 0.98) and for arthralgia (sensitivity of 0.80 and specificity of 0.97). The diagnostic criteria for intra-articular disorders have lower sensitivity and specificity values, and imaging methods are thus recommended to confirm the diagnosis, when needed.

Axis II consists of instruments for screening and more comprehensive assessment of psychosocial risk factors. The shorter screening instruments, primarily for use in basic health care, include questionnaires about pain intensity and pain-related disability, psychological distress, jaw functional limitations, and parafunctional behaviors. In addition, a pain drawing is used to estimate the locations of TMD and body pain. A more comprehensive version is established for assessing jaw functional limitations, as well as depression, non-specific physical symptoms and anxiety symptoms in more detail.

2.4 Oral Health-Related Quality of Life (OHRQoL)

Oral Health-Related Quality of Life (OHRQoL) includes subjectively evaluated physical, psychosocial and social aspects of oral health (Locker & Allen, 2007). The Oral Health Impact Profile (OHIP) was developed and evaluated in 1994 by Slade and Spencer. The OHIP offers a reliable and valid instrument for detailed measurement of the social impact of oral disorders and has potential benefits for clinical practice and decision-making as well as research purposes.

The OHIP is a questionnaire which is organized into seven sections (functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability and handicap) to evaluate the functional and psychosocial outcomes of oral conditions (Slade & Spencer, 1994). OHIP-14, the shortened version of OHIP, is widely used and has been validated for multiple languages (Slade, 1997).

It can be suggested that especially chronic TMD impairs individuals' quality of life, particularly OHRQoL. Studies have shown a substantial negative impact on OHRQoL in patients with TMD (Bayat et al., 2018; Yap et al., 2021). This association has been shown in population-based studies as well (Bäck et al., 2020; Oancea et al., 2020). Studies have also shown that TMD impair OHRQoL especially through pain (John et al., 2007; Reissmann et al., 2007).

Based on a systematic review, it has been suggested that TMD impair the OHRQoL particularly in patients with psychological impairments (Oghli et al., 2020). In a study by Yap et al. (2021) on TMD patients, it was found that middle-aged or older patients had similar psychological profiles to younger patients but experienced lower OHRQoL in the physical pain domain. Based on a recent clinical study (Cao et al., 2022), both TMD chronicity and subtypes influenced OHRQoL. TMD chronicity appeared to affect OHRQoL only in painful TMD conditions. Future research on the impact of TMD on OHRQoL should strive to stratify patients by TMD chronicity and subtypes.

Nonetheless, the number of studies concerning TMD and OHRQoL is relatively low and further studies are needed to evaluate the level of impaired OHRQoL in TMD and for investigating the psychosocial aspects in this association.

2.5 Conscripts as a study population

Conscripts make up a special population of mainly young men. Representing the vast majority of any male age cohort, conscripts form an ideal study population for cross-sectional studies. In addition, it is also easy to investigate many people and from all over the country under a short time during military service.

> *"Military service includes conscript service, refresher training, extra service and service during mobilization as well as participation in call-ups and the examination of fitness for service. Call-ups form the first concrete step into military service. The civic duty of military service is defined in the second chapter of the law on conscription (called Conscription Act). This duty affects all Finnish men and begins when a man turns 18. It continues till he reaches the age of 60. This means a man is liable for military service and that he is either in service, in the reserve or in the auxiliary reserve."*
>
> *(Conscription Act 1:2 §).*

Nowadays, mandatory military service covering entire age cohorts is rare. Finland is one of the countries, similarly to Israel and Turkey, where the vast majority of male age cohorts perform military service.

2.5.1 International studies

Internationally, many studies have been conducted investigating oral health among conscripts. These studies deal mainly with dental caries and traumas (Levin et al., 2003, 2004) and oral health in general (Feldens et al., 2016; Stona et al., 2021).

Schindler et al. (2020) studied oral health status among conscripts with and without prior active duty in the U.S. Armed Forces. They examined differences in oral health status between veterans and nonveterans in the U.S. to determine how various factors, including socioeconomic factors, general health, and tobacco use, impact the oral health of former service members. They found that military service was not associated with periodontitis or untreated dental caries; however, adverse oral health conditions, primarily related to periodontitis, were more common among veterans.

Health habits among military personnel have also been studied: Park et al. (2021) studied differences in problem alcohol drinking by military service type among military personnel in South Korea. In a sample of 2 252 male professional military persons, they found that the prevalence of problem drinking was 16.4% for the Army, 34.5% for the Navy and 32.1% for the Air Force. Additionally, factors that associated with problem drinking were low sleep satisfaction, poor family support, smoking, marital status (married) and poor subjective oral health, depending on the military service type. Especially smoking was associated with problem drinking in the Navy and in the Air Force.

2.5.2 National studies

Nationally, a lot of research has been done on dental health (Kämppi et al., 2013, 2014, 2016; Tanner et al., 2013) and general health among conscripts (Kronström et al., 2021; Santtila et al., 2018). The studies of Kämppi et al. and Tanner et al. investigated the prevalence and polarization of dental caries, the geographical distributions of dental caries prevalence and associated factors, and the screening criteria in estimating restorative treatment need.

Tanner et al. (2014) studied the association of smoking and snuffing with dental caries occurrence in Finnish conscripts in a cross-sectional study. They found that 39.4% reported daily smoking and 9.0% daily snuffing. The need for restorative treatment among smokers was 2-fold compared to non-smokers. In addition, smoking was statistically significantly associated with other harmful health behaviors.

Kronström et al. (2021) investigated psychosocial well-being, psychopathology, substance use, suicidality, bullying, and sense of coherence among conscripts from 1999 to 2009. They found reductions in the prevalence of suicidal thoughts and the use of illicit drugs, but being drunk at least once a week increased. Santtila et al. (2018) studied cardiorespiratory and muscle fitness among conscripts during the years 1975–2015. They found that the increase in mean body mass of conscprits had slowed, but their aerobic capacity had still decresed. In addition, the percentage of conscprits exhibiting low muscle fitness had risen.

Although there are studies investigating the association of physical activity and physical fitness with general pain conditions, there is a lack of studies concerning their role especially in TMD symptoms, which creates a need for further population-based studies. Physical tests are included routinely in the service of conscripts, which offers a good opportunity to investigate the association of both physical fitness and physical activity as well as other lifestyle factors, such as use of psychoactive substances, with the presence of TMD symptoms.

3 Aims of the study

The general aim of the study was to investigate the prevalence of TMD and its association with health behaviors and OHRQoL.

More specifically, the aims were:

1. to evaluate the prevalence of TMD symptoms and their associations with alcohol consumption and smoking habits among Finnish conscripts
2. to evaluate the association of TMD symptoms with physical fitness, physical activity, and body mass index (BMI) among Finnish conscripts
3. to evaluate the association between psychosocial aspects of TMD and OHRQoL, and secondly, to investigate the gender differences in these associations using patient and non-patient groups.

The research hypotheses were that:

1. TMD symptoms are relatively frequent among Finnish conscripts, and they associate with frequent smoking and higher alcohol consumption.
2. TMD symptoms associate with lower capacity in physical tests and physical activity and overweight among Finnish conscripts.
3. Psychosocial burden associates with OHRQoL. The TMD patient group has significantly poorer OHRQoL than the non-patient group, and the association is stronger for women than men.

4 Subjects and methods

4.1 Study populations

4.1.1 Studies I and II

The epidemiologic, cross-sectional study was performed during January and July 2011 in the Finnish Defense Forces. The total number of draftees who entered military service in the Finnish Defense Forces in 2011 was 25 989 men and 503 women, and of those, 14 458 randomly chosen conscripts underwent oral health screening (Tanner et al., 2013). Finally, the three largest age groups, born in 1990, 1991 and 1992 (19–21 years old at the time of the study), of those who were screened, were selected for the study. The final study population consisted of a total of 13 819 conscripts, 13 564 of whom were men and 255 women (Figure 1). All in all, the study group comprised 95.6% of all screened conscripts in the Finnish Defense Forces in 2011. For investigating individual background factors and health behaviors the conscripts had an opportunity to answer a computer-aided questionnaire (Anttonen et al., 2012). In the end, 8 678 conscripts underwent the clinical examination and responded to the questionnaire, and data on them was included in the analyses.

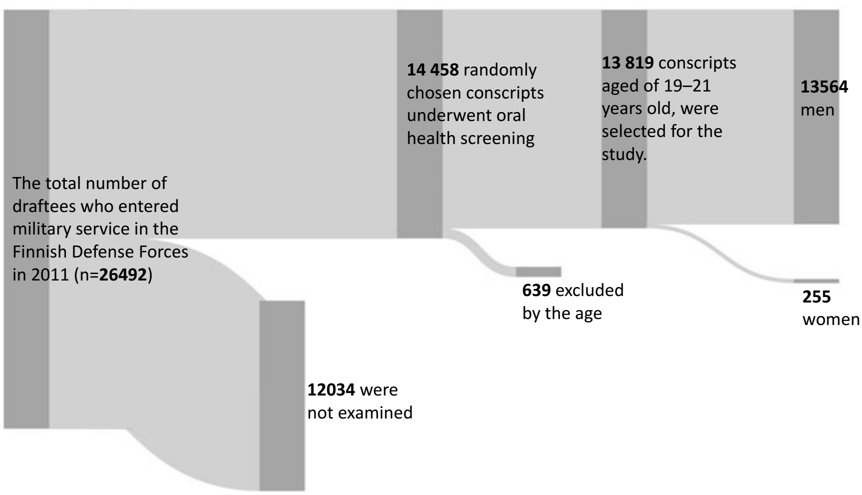

Fig. 1. Study population (studies I and II).

4.1.2 Study III

Study III population consisted of a total 149 subjects, including a patient and non-patient group. The patient group included a total of 79 consecutive TMD patients referred for diagnosis and treatment of TMD to the Oral and Maxillofacial Department, Oulu University Hospital, Finland. The patient group consisted of 18 men (22.8%) and 61 women (77.2%), and the mean age was 43.5 years (SD 13.1 years). The inclusion criteria for the patient group were at least one diagnosis of TMD according to the RDC/TMD Axis I criteria (Dworkin & LeResche, 1992), at least 20 years of age, and lack of general diseases that might affect temporomandibular disorders.

The non-patient group included a total of 70 dental students from the University of Oulu, Finland. The non-patient group consisted of 23 men (32.9%) and 47 women (67.1%), and the mean age was 25.3 years (SD 6.5 years).

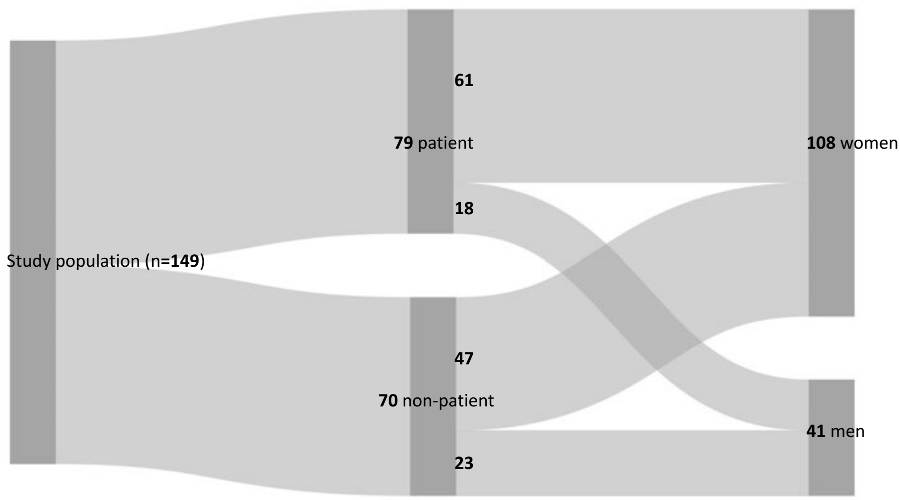

Fig. 2. Study population (study III).

4.2 Data Collection

4.2.1 TMD symptoms as outcome variables (I and II)

The questionnaire concerned the time before entering military service. The questionnaire consisted of a total of 50 questions, of which the following six questions inquired about facial pain and symptoms of TMD: “Have you had pain or ache in the face during the last year?”; “Have you had pain or ache in the jaws during the last year?”; and “Have you had symptoms in the area of the jaw joint (pain at jaw rest, pain on jaw movement, TMJ clickings, difficulties in mouth opening)?”. The answer options to these questions were “no”, “now and then/occasionally”, “fairly often” and “often or continuously”. In study II, answers were dichotomized as yes/no; the answer yes included “now and then/occasionally”, “fairly often” and “often and continuously”. In Study III, the answer options were dichotomized as yes/no, with no including “no” or “now and then/occasionally” and yes including “fairly often” and “often or continuously”.

4.2.2 Socio-demographic factors (I and II)

Data on multiple socio-demographic factors (education, parental status, chronic disease, dental attendance, and dental symptoms) were obtained with questions. The information about gender was obtained from the Defense Forces’ database.

Socio-economic and health-related status were determined by the following questions: “Your education: Comprehensive school, Vocational School, Vocational school and matriculation exam or gymnasium, Matriculation exam or gymnasium, University of applied sciences, College or university, or Other”, and “Do you have any disease (that has lasted for more than 2 months) that requires medication?” (yes/no)” and “Do you have dental symptoms/tooth ache?” (yes/no). The time from the last visit to a dentist or dental hygienist was determined using a question with the following response options: “less than a year”, “1 to 2 years”, “3 to 4 years”, “5 years or more”, and “don´t remember”. These options were dichotomized as “0–2 years” and “3 years or more”. Parental marital status was defined by the following options: “Your parents: live together/ divorced”

4.2.3 Use of psychoactive substances (I) and physical activity (II)

Use of psycho-active substances was determined by the following questions: "Do you smoke?" (answers: No, 1–5 cigarettes daily, 10–20 cigarettes daily and > 20 cigarettes daily), "Do you consume alcohol?" (answers: No, Less than once a month, About once a month, About every other week, About every week and More than once a week) and "Do you use snuff?" (answers: Never or hardly ever, Every day or almost every day and Occasionally).

Physical activity in the last 6 months, before entering military service, was inquired with the following question: "During the past 6 months, how often have you exercised or done sports?". The answer options were: "Never or hardly ever", "Every day or almost every day" and "Occasionally". Current physical activity was inquired with the following question: "How often do you do physical exercise?". The answer options were: "Never", "1–2 times a month", "1–2 times a week", "3–4 times a week" and "More than 5 times a week".

4.2.4 Physical tests (II)

The conscripts performed and were evaluated by four different physical tests: Cooper test (meters in 12 minute of running), push-ups (number in 60 seconds), sit-ups (number in 60 seconds) and standing long jump (meters). Trained personnel guided and measured all the tests; the Cooper test was on a separate day than the muscle fitness tests (push-ups, sit-ups and standing long jump). The Cooper test was done first, with a 10- to 15-minute warm-up, on a sports field. The muscle fitness tests were performed in a gym.

The results and cut-offs for the physical test are based on the Finnish Defense Force instructions (Pihlainen et al., 2011) and on international standards (Cooper, 1968; Fletcher et al., 1992). All results of physical test were dichotomized (poor/good); the Cooper test (poor 0–2 799 m), push-ups (poor 0–37 repetitions), sit-ups (poor 0–42 repetitions) and standing long jump (poor 0–2.20 meters). Other results were considered good.

The height and weight of the conscripts were measured when they entered military service, and the BMI values were calculated. BMI values were dichotomized based on the commonly accepted limits set by the World Health Organization (WHO 2021); conscripts with BMI ≥ 25 were considered overweight and those with BMI < 25 as normal weight.

4.2.5 OHRQoL (III)

The questionnaire consisted of the validated Finnish shortened version of the Oral Health Impact Profile (OHIP-14) (Lahti et al., 2008). The OHIP-14 questionnaire includes dimensions of oral health-related quality of life (OHRQoL): functional limitation, physical pain, psychological discomfort, physical disability, psychosocial disability, social disability, and handicap.

The OHIP prevalence and OHIP severity were calculated for each subject. The prevalence of OHIP was calculated as the percentage of those subjects who reported at least one problem occasionally, fairly often, or very often. The OHIP severity was calculated by summing the ordinal values for the 14 items, taking only into account experienced impacts of "occasionally" or "hardly ever".

4.2.6 RDC/TMD Axis II variables (III)

The psychosocial factors were inquired based on the Finnish translation of the RDC/TMD Axis II instruments (Suvinen et al., 2010), including Graded Chronic Pain Scale 1.0 (GCPS 1.0), and questionnaire on somatization and depression symptoms. The GCPS grades were determined according to Dworkin and LeResche as follows: "grade 0 = no TMD pain in previous six months", "grade I = low disability-low intensity pain", grade II = low disability-high intensity pain", grade III = high disability-moderately limiting", and "grade IV = high disability-severely limiting". GCPS was dichotomized as grade 0/grade I–IV for the logistic regression analyses.

Using SCL-90-R questionnaires, patients reported how much they had suffered during the last month from symptoms of depression (20 questions) and non-specific physical symptoms including pain items (12 questions) or without pain items (7 questions) on a scale 0–4 (0 = not at all, 4 = very much) (Dworkin & Le Resche, 1992).

Somatization (both pain items included and excluded) and depression were classified as normal, moderate and severe, based on reference values as suggested by Dworkin and LeResche (1992). Somatization (pain items included and pain items excluded) and depression were further dichotomized as normal/moderate or severe.

4.3 Statistical analyses

4.3.1 Study I

For the statistical analyses, the prevalence of TMD symptoms was calculated by gender. The associations of TMD symptoms with explanatory variables (the frequency of smoking, consumption of alcohol and snuff) were evaluated using chi-square tests and described by crude odds ratios (ORs) and their 95% confidence intervals (CI). For assessing the associations between outcome and explanatory variables when adjusting for background factors (gender, education, parental status, chronic disease, and toothache), unconditional multivariable logistic regression analysis was used. The associations were described by ORs and their 95% CIs, and the statistical significance was set at $p < 0.05$. All analyses were executed and the figures drawn using the SPSS software (version 18.0, SPSS) and R software (version 2.13.2 patched, R Foundation for Statistical Computing).

4.3.2 Study II

The chi-square test was used to evaluate the associations between TMD symptoms and explanatory variables (physical fitness tests, physical activity, and BMI). Unconditional multivariable logistic regression analysis was used to evaluate the associations between outcome (self-reported facial pain and symptoms of TMD) and explanatory variables (physical fitness tests, physical activity, and BMI). The ORs and 95% CIs were calculated, and statistical significance was set at $p < 0.05$. All analyses were executed and figures drawn using the SPSS software (version 25.0, SPSS, Inc., Chicago, IL, USA) and R software (version 2.12.2, R Foundation for Statistical Computing).

4.3.3 Study III

In study III, OHIP prevalence and OHIP severity were calculated by each subgroup of the RDC/TMD Axis II. Chi-square tests were used to evaluate the association between Axis II subscales and OHIP prevalences, stratified by gender and group status. The statistical significance of the associations between Axis II subscale categories and OHIP severity was evaluated using one-way Anova test. Logistic regression analyses with OHIP prevalence (dependent variable) and GCPS, somatization (with pain items included and pain items excluded) and depression as independent variables were conducted. All the models were adjusted for age, gender and group. Interaction coefficients between each independent variable and group and gender were calculated. All analyses were executed and figures drawn using the SPSS software (version 17.0, SPSS, Inc., Chicago, IL, USA), and statistical significance was set at $p < 0.05$.

4.4 Ethical considerations

4.4.1 Studies I and II

The subjects gave their informed consent for the use of the data, and only data from those who had given their consent were used in the study. For the analyses, IDs were excluded. The research plan was approved by the Ethics Committee of the Northern Ostrobothnia Hospital District on 29 March 2010. The Center for Military Medicine and the Defense Staff gave permission for the study in June 2010 (AG14218/23 June 2010).

4.4.2 Study III

The subjects gave their informed consent for the use of the data, and only data from those who had given their consent were used in the study. The research plan was approved by the Ethics Committee of the Northern Ostrobothnia Hospital District (29/2007).

5 Results

5.1 Prevalence of TMD symptoms (I)

Among conscripts, the most prevalent TMD symptoms were TMJ clicking and jaw pain (Table 1). Most of the TMD symptoms were reported only occasionally. Self-reported TMD symptoms varied between 5.8% and 27.8%. The prevalence of all TMD symptoms was higher among females, except TMJ clicking, the differences being statistically significant in TMJ pain at jaw rest ($p = 0.002$) and difficulties in jaw opening ($p < 0.001$). The prevalence of all TMD symptoms except TMJ clicking was significantly higher among those with lower education than the rest. Low number of dental visits (3 years or more since the last visit) was also significantly associated with TMJ pain at jaw rest ($p = 0.033$) and TMJ pain on jaw movement ($p = 0.023$) (Table 1).

Table 1. Prevalence of TMD symptoms by gender, socioeconomic and health- and lifestyle-related factors among Finnish conscripts (n = 8 699).

Factor	Facial pain (%)	Jaw pain (%)	TMJ clicking (%)	TMJ pain at jaw rest (%)	TMJ pain on jaw movement (%)	Difficulties in jaw opening (%)
Gender						
- Male	13.6	25.3	27.8	7.3	13.4	5.8
Never	86.4	74.7	72.2	92.7	86.6	94.2
Occasionally	12.9	22.9	22.0	6.6	12.2	4.9
Fairly often	0.6	2.0	3.8	0.5	1.0	0.6
Frequently or continuously	0.2	0.3	2.1	0.1	0.2	0.3
- Female	14.9	33.8	26.4	14.9	18.9	12.8
Never	85.1	66.2	73.6	85.1	81.1	87.2
Occasionally	14.2	29.1	19.6	12.8	17.6	8.1
Fairly often	0.7	4.1	5.4	2.0	0.7	2.0
Frequently or continuously	0.0	0.7	1.4	0.0	0.7	2.7
Education						
Higher education	13.7	25.3	28.0	7.4	13.5	6.1
Primary school only	16.9	30.1	29.0	11.0	17.6	7.9
Parental Status						
Live together	12.9	24.4	27.5	7.3	13.3	5.7
Divorced	15.7	29.1	29.3	8.4	15.1	7.2

Factor	Facial pain (%)	Jaw pain (%)	TMJ clicking (%)	TMJ pain at jaw rest (%)	TMJ pain on jaw movement (%)	Difficulties in jaw opening (%)
Chronic disease						
No	13.6	25.1	27.4	7.5	13.4	6.0
Yes	17.4	32.3	34.9	9.5	18.1	7.9
Consumption of alcohol						
Once a month or less	12.1	23.4	26.6	6.6	12.0	5.4
Every second week	12.8	25.1	27.4	7.0	13.3	6.2
Once a week or more	17.8	29.7	30.8	9.6	16.8	6.9
Smoking						
No	11.8	23.1	27.7	6.5	12.0	5.4
1-5 cigarette/d	14.8	26.8	25.3	8.0	13.1	5.7
10-20 cigarettes/d	16.8	29.8	29.2	8.6	16.8	7.3
20+ cigarettes/d	25.7	39.2	33.3	18.0	25.7	9.9
Use of Snuff						
No	13.0	25.2	27.9	7.3	13.2	6.0
Yes	16.9	27.0	27.6	8.1	15.5	6.1
Most recent dental visit						
0-2 years	13.4	25.2	27.9	7.2	13.2	5.8
3 years or more	14.8	26.5	27.6	8.6	15.5	6.7
Toothache						
No	11.5	22.0	26.4	5.9	11.6	5.1
Yes	26.1	45.6	36.0	16.3	25.0	10.8

5.2 Association of TMD symptoms with the use of psycho-active substances (I)

The prevalence of TMD symptoms by use of snuff, frequency of smoking and use of alcohol is presented in Table 2 and Figure 3. The prevalence of all TMD symptoms was significantly higher among smokers than non-smokers and among those who reported toothache. The prevalence of facial pain ($p < 0.001$), jaw pain ($p < 0.001$), TMJ pain at jaw rest ($p < 0.001$) and TMJ clicking ($p = 0.002$) was higher with increasing frequency of alcohol consumption. In addition, the prevalence of facial pain ($p < 0.001$) and TMJ pain on jaw movement ($p = 0.009$) was significantly higher among those who used snuff than among those who did not. The risk for all TMD symptoms except TMJ clicking was increased among those using alcohol (once a week or more) and among smokers (at least 10 cigarettes per day) (Table 2, Figure 3).

Table 2. Associations of TMD symptoms with frequency use of snuff, consumption of alcohol, and smoking, as described by Crude Odds Ratios (OR) and 95% Confidence Intervals (CI).

	Facial pain		Jaw pain		TMJ clicking		TMJ pain at jaw rest		TMJ pain on jaw movement		Difficulties in jaw opening	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Use of Snuff												
No	1		1		1		1		1		1	
Yes	1.36	(1.18–1.58)	1.1	(0.97–1.24)	0.99	(0.87–1.11)	1.12	(0.92–1.37)	1.21	(1.04–1.41)	1.02	(0.81–1.28)
Consumption of alcohol												
Once a month or less	1		1		1		1		1		1	
Every second week	1.08	(0.93–1.25)	1.10	(0.98–1.23)	1.04	(0.93–1.16)	1.06	(0.88–1.29)	1.13	(0.98–1.31)	1.18	(0.96–1.45)
Once a week or more	1.59	(1.37–1.84)	1.38	(1.23–1.56)	1.23	(1.09–1.38)	1.49	(1.23–1.82)	1.48	(1.27–1.72)	1.29	(1.04–1.62)
Smoking												
No	1		1		1		1		1		1	
1–5 cigarette/d	1.31	(1.08–1.57)	1.22	(1.06–1.42)	0.89	(0.77–1.03)	1.26	(0.99–1.61)	1.12	(0.92–1.35)	1.06	(0.80–1.40)
10–20 cigarettes/d	1.50	(1.30–1.73)	1.41	(1.26–1.59)	1.07	(0.96–1.20)	1.33	(1.10–1.61)	1.48	(1.28–1.71)	1.36	(1.11–1.67)
20+ cigarettes/d	2.59	(1.90–3.54)	2.16	(1.64–2.85)	1.31	(0.98–1.74)	3.20	(2.23–4.58)	2.56	(1.87–3.49)	1.23	(1.23–3.07)

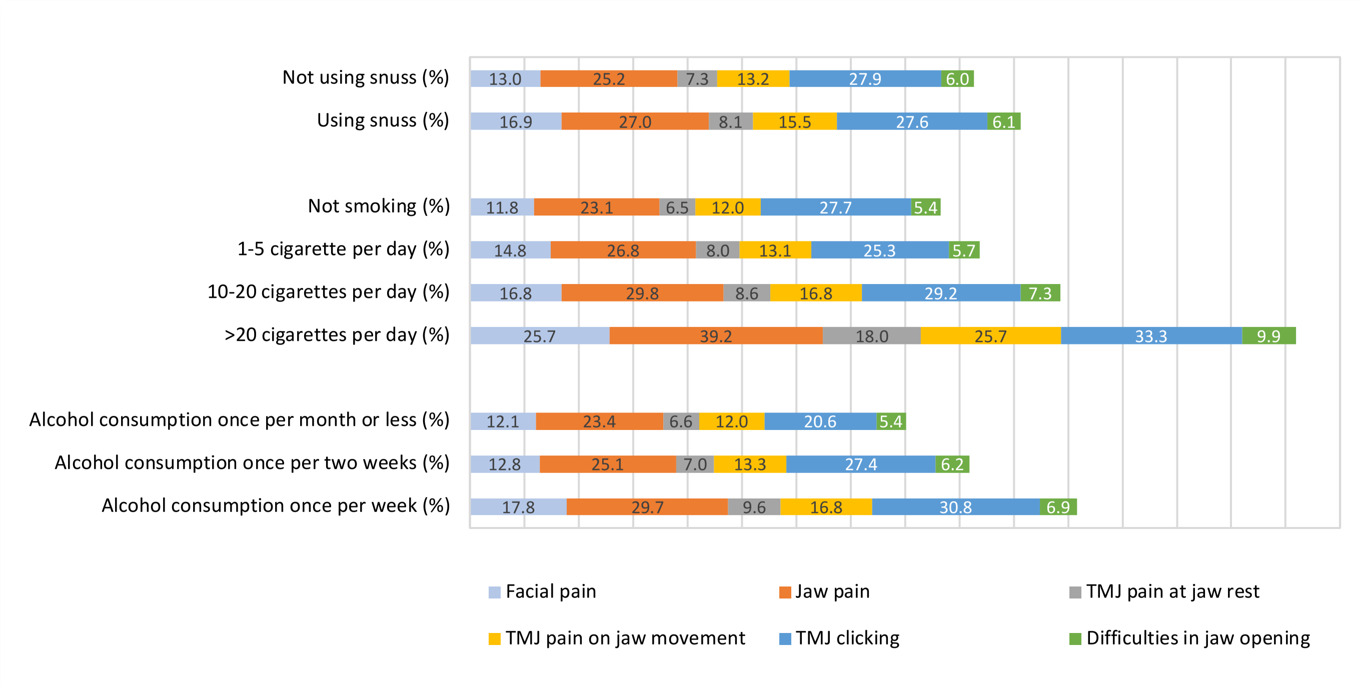

Fig. 3. Prevalence of TMD symptoms by use of snuff, frequency of smoking and use of alcohol (%).

5.3 Association of TMD symptoms with physical activity and fitness (II)

The prevalence of TMD symptoms by physical activity and fitness is presented in Figure 4. The prevalence of all TMD symptoms was significantly higher among those with current low physical activity compared to active ones ($p < 0.001$ for jaw pain, TMJ pain at jaw rest, TMJ pain on jaw movement and TMJ clicking, $p = 0.001$ for facial pain and $p = 0.006$ for difficulties in jaw opening). Furthermore, the prevalence of all TMD pain symptoms except facial pain and difficulties in jaw opening was significantly higher in the last six months among physically inactive conscripts compared to active ones ($p < 0.001$ for TMJ clicking, $p = 0.001$ for facial pain and TMD pain at jaw rest, $p = 0.005$ for TMJ pain on jaw movement). The prevalence of jaw pain ($p < 0.001$), TMJ pain at jaw rest ($p = 0.002$), facial pain ($p = 0.003$) , and TMJ pain on jaw movement ($p = 0.010$) was significantly higher among those who were overweight (BMI ≥ 25) compared to conscripts who were normal weight.

Compared to good success, poor success in physical tests (Cooper test, push-ups, sit-ups and standing long jump) indicated higher prevalence of TMD symptoms. Poor push-up results associated significantly with jaw pain ($p = 0.002$), TMJ pain at jaw rest ($p = 0.001$), facial pain ($p = 0.015$), TMJ pain on jaw movement ($p = 0.017$), and TMJ clicking ($p = 0.006$). Subjects with poor Cooper test results reported significantly more TMJ problems: higher prevalence of TMJ pain at jaw rest ($p = 0.047$), TMJ pain on jaw movement ($p = 0.002$) and TMJ clicking ($p < 0.001$). Subjects with poor sit-up results reported significantly more jaw pain ($p = 0.033$), TMJ pain at jaw rest ($p = 0.004$), TMJ clicking ($p = 0.003$), and difficulties in jaw opening ($p = 0.020$).

Based on logistic regression model, jaw pain was significantly associated with physical inactivity (OR 1.22, 95% CI 1.05–1.41), overweight (BMI ≥ 25) (OR 1.15, 95% CI 1.03–1.30) and female gender (OR 1.51, 95% CI 1.01–2.27). TMJ pain at jaw rest was significantly associated with physical inactivity OR 1.28, 95% CI 1.01–1.62), overweight (BMI ≥ 25) (OR 1.23, 95% CI 1.01–1.49) and female gender (OR 2.26, 95% CI 1.29–3.95). Jaw pain was significantly associated with poor push-up results (OR 1.19, 95% CI 1.01–1.40) and overweight (BMI ≥ 25) (OR 1.19, 95% CI 1.03–1.37). TMJ pain at jaw rest was significantly associated with overweight (OR 1.33, 95% CI 1.05–1.68) and female gender (OR 2.59, 95% CI 1.37–4.88).

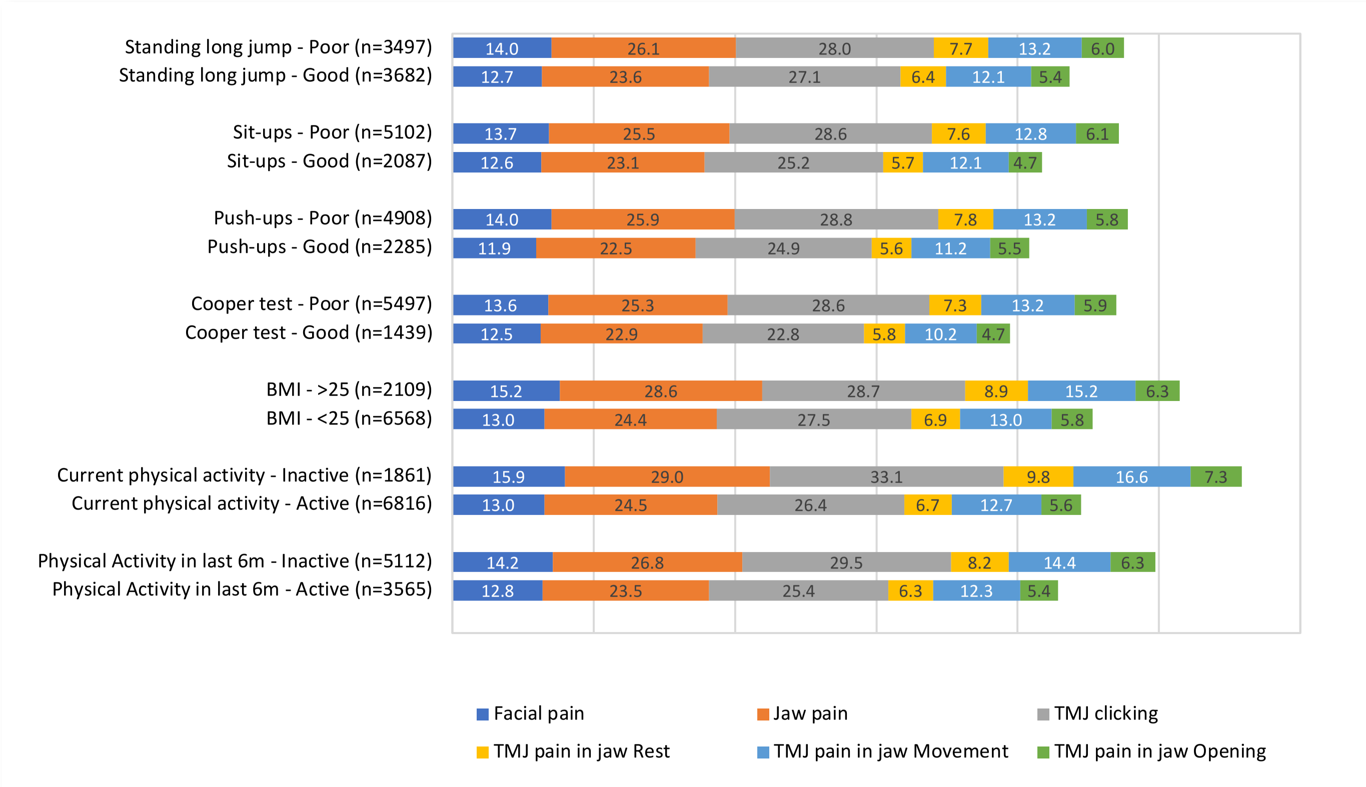

Fig. 4. Prevalence of TMD symptoms by physical fitness, BMI, and physical activity (%).

5.4 Association of TMD with OHRQoL and psychosocial factors (III)

The prevalence of OHIP was 33.3% in the non-patient group and 90.9% in the patient group. In those scoring higher on all RDC/TMD Axis II profile subscales, the OHIP prevalence was higher. All RDC/TMD Axis II subscales were significantly associated with OHIP prevalence in the non-patient group. The mean OHIP prevalence was 56.4% among men and 67.6% among women. The OHIP prevalence associated with all RDC/TMD Axis II subscales among women and with GCPS and somatization (with pain items excluded) among men.

The mean OHIP severity score was 3.0 (SD 5.5) in the non-patient group and 15.7 (SD 10.5) in the patient group. All Axis II subscales were significantly associated with OHIP severity in the non-patient group. In the patient group, OHIP severity was significantly associated with both somatization subscales, with pain items excluded and included. The mean OHIP severity score was 6.0 (SD 6.7) in men and 11.3 (SD 11.5) in women. Women had higher OHIP scores than men in all Axis II subscales. All Axis II subscales except depression were significantly associated with OHIP severity in men. GCPS was significantly associated with OHIP severity among women (Table 3).

Table 3. OHIP prevalence and severity in the patient and non-patient group and among men/women.

					OHIP prevalence				OHIP severity			
	P[2]	NP[3]	Men	Women	P	NP	Men	Women	P	NP	Men	Women
	n (%)	n (%)	n (%)	n (%)	%	%	%	%	%	%	%	%
GCPS[1] grade												
0	25 (31.3)	45 (64.3)	21 (53.8)	46 (45.1)	84.0	20.5	28.6	50.0	13.0	1.2	1.6	7.1
I	19 (24.1)	19 (27.1)	10 (25.6)	24 (23.5)	88.9	62.5	80.0	75.0	14.2	5.1	8.3	10.5
II	33 (41.8)	6 (8.6)	8 (20.5)	30 (29.4)	96.9	50.0	100.0	86.7	18.3	10.8	14.5	17.8
III	1 (1.3)	-	-	1 (1.0)	100.0	-	-	100.0	27.0	-	-	27.0
IV	1 (1.3)	-	-	1 (1.0)	100.0	-	-	100.0	16.0	-	-	16.0
p-value					0.539	0.006	0.001	0.011	0.278	0.000	0.000	0.004
Depression												
Normal	43 (54.4)	46 (65.7)	30 (76.9)	58 (56.9)	88.4	21.7	46.7	56.9	12.95	2.3	4.9	8.7
Moderate	21 (26.6)	14 (20.0)	7 (17.9)	28 (27.5)	100.0	64.3	85.7	85.7	19.38	3.8	9.9	14.0
Severe	12 (15.2)	6 (8.6)	2 (5.1)	16 (15.7)	91.7	50.0	100.0	75.0	20.17	6.5	9.0	16.4
p-value					0.269	0.008	0.076	0.022	0.278	0.000	0.572	0.063
Somatization[4]												
Normal	27 (34.2)	45 (64.3)	28 (71.8)	44 (43.1)	85.2	22.2	46.4	45.5	12.1	1.6	4.5	6.2
Moderate	29 (36.7)	14 (20.0)	9 (23.1)	34 (33.3)	93.1	64.3	77.8	85.3	18.0	3.8	9.2	14.5
Severe	12 (15.2)	7 (10.0)	2 (5.1)	24 (23.5)	100.0	42.9	100.0	83.3	17.9	10.3	12.5	16.3
p-value					0.171	0.012	0.114	0.000	0.018	0.180	0.027	0.086
Somatization[5]												
Normal	35 (44.3)	46 (65.7)	29 (74.4)	52 (51.0)	88.6	23.9	44.8	55.8	14.1	1.5	4.3	8.4
Moderate	24 (30.4)	16 (22.9)	8 (20.5)	32 (31.4)	91.7	56.3	87.5	75.0	15.5	4.4	10.3	11.3
Severe	17 (21.5)	4 (5.7)	2 (5.1)	18 (17.6)	100.0	50.0	100.0	88.9	20.1	14.0	12.5	19.9
p-value					0.356	0.047	0.043	0.020	0.060	0.000	0.008	0.120

[1] Graded Chronic Pain Status, [2] Patients, [3] Non-Patients, [4] Pain items included, [5] Pain items excluded

6 Discussion

6.1 Key findings

One of the main findings of this thesis was that the prevalence of self-reported TMD symptoms was relatively high among Finnish conscripts, with the highest prevalences seen for jaw pain and TMD clicking (approximately one fourth of the study population). Additionally, TMD symptoms associated with health behaviors, such as daily smoking, increased frequency of alcohol consumption, low physical activity and overweight, whereas good cardiorespiratory and musculoskeletal fitness associated inversely with TMD pain. In addition, TMD patients had significantly poorer OHRQoL than non-patients. Psychosocial risk factors of TMD, i.e., pain-related disability, depression and somatization symptoms, associated with OHRQoL among both genders.

6.2 Study populations and methods

6.2.1 Studies I and II:

Mandatory military service provides a unique opportunity to conduct epidemiological studies on specific nationwide age cohorts. To our knowledge, there are no similar studies available on this topic and with a corresponding study population. The study population was large, which minimized the effect of low power due to small sample size, and it is thus indicative of males in this age group. The clinical oral health examination, which is obligatory and carried out on all conscripts, limits the number of dropouts.

The questionnaire was filled in at the same visit as the oral health examination was performed. Because the examinations were carried out during the first two weeks of military service, the outcomes can be considered to indicate the health status and behaviors before the service. Not all those who were clinically examined had time to answer the questionnaire; however, the clinical status of the respondents and non-respondents was not different (Kämppi et al., 2014). So, it can be speculated that the results indicate the status in the entire population examined.

The study group consisted of young healthy adults, mainly men, who had no severe diseases or conditions. All participants went through the draft and health inspection and were evaluated to be fit for demanding physical and mental tasks before entering and during military service. Even if four fifths of males entered military service and the study population covered the age cohort better than in most population-based studies, the study population does not represent the entire age cohort. In most cases, problems with physical or mental health are the reason for not entering military service (Lehesjoki, 2018). On the other hand, some individuals choose civil service instead of military service and they were not included here. TMD symptoms and conditions are known to correlate with general diseases. Thus, it can be speculated that TMD symptoms may be even more common among the young adult population than presented here. Military service is voluntary for females; thus, the number of females was low, which is why the female group can be regarded as even more selected than the general male population.

6.2.2 Study III:

In study III, the non-patient group consisted entirely of dental students (n = 70, 32.9% men, mean age = 25.3 years). It can be assumed that they experienced more stress and depression than the normal working adult population and their awareness of TMD symptoms may have affected their report of TMD symptoms. On the other hand, the patient population consisted of TMD patients who had been referred to the Oral and Maxillofacial Department, Oulu University Hospital, Finland, for diagnosis and treatment of TMD. It may be suggested that the patient population of study III consisted of challenging and chronic TMD patients. The sample size was calculated with power analyses (Qvintus et al., 2015). However, the number of patients in distinct subgroups remained low.

6.3 Prevalence of TMD symptoms among conscripts

The study population comprised only young healthy conscripts (mean age 19.6 years) with no severe physical or mental disabilities; nevertheless, the results show that the prevalence of self-reported TMD is relatively high among young adults. There exist no other studies concerning TMD symptoms among conscripts, which adds the value of the present study. TMJ clicking and jaw pain were the most common self-reported TMD symptoms, representing a fourth to a third of the study population. The number of female conscripts (n = 255) was low; nonetheless, the gender difference in the prevalence of TMD symptoms was distinct: all TMD symptoms were more frequent among female conscripts, except for the prevalence of TMJ clicking. These gender differences are in line with earlier studies (Johansson et al., 2004; Jussila et al., 2017; Lövgren et al., 2016; Nilsson et al., 2005; Qvintus et al., 2020; Yekkalam et al., 2014).

In the present study, questions about TMD symptoms during the preceding year were used. The prevalence of self-reported facial pain was 13.6% for males and 14.9% for females, and corresponding levels for jaw pain were 25.3% for males and 33.8% for females. Lower prevalence levels have been shown in other studies on young adults or adolescents, which may be due to the fact that they used questions about current TMD symptoms once a week or more. The study of the Northern Finland 1966 Birth Cohort used a questionnaire on TMD symptoms identical to the one in the present study (Rauhala et al., 2000). The cohort members were 31–32 years old at the time of the study. In that study, they found prevalence levels for facial pain of 12% among males and 18% among females. The results are approximately at the same level as in the present study (14 and 15%, correspondingly). In the present study, toothache had the strongest association with all TMD symptoms. It can be assumed that not all symptoms reported here may be related to TMD. For instance, symptoms of erupting wisdom teeth are quite common around the age of 20 and can be one of the explanations.

6.4 Psychoactive substances

The present study showed that smoking 20 cigarettes or more a day was significantly associated with all TMD pain symptoms. The association between smoking and TMD has been investigated in previous studies, and the results have been contradictory. Wänman (2005) found in a follow-up study that smoking was not related to the presence or development of TMD signs or symptoms among an adult population (age 30–65 years). For their part, Sanders et al. (2012) found that smoking increased the incidence of the first onset of TMD in females in young adulthood. Daily tobacco use has also been shown to correlate significantly with TMD symptoms in 50-year-old subjects (Johansson et al., 2004). Melis at al. (2010) found that TMD pain intensity was higher in smokers compared to non-smokers, and it also associated with the number of cigarettes smoked daily. Our findings are in line with these three studies, showing an association between smoking and TMD pain symptoms. The explanation for these associations remains unknown. Previously, it has been shown that smoking increases the risk for different pain conditions, pain persistence, severity and pain reactivity (LaRowe & Ditre, 2020).

Smoking may contribute to dysregulated pain processing through nicotine-specific and general neurobiological mechanisms (LaRowe & Ditre, 2020).

In this study, the use of snuff was significantly associated with facial pain, and the prevalence of most TMD symptoms was higher among those who used snuff. The association between snuff use and TMD has not been studied earlier, but Rintakoski, Ahlberg, Hublin, Lobbezoo et al., (2010) have studied the association between tobacco products use (including smokeless tobacco) and bruxism. They found that the use of smokeless tobacco emerged as an independent risk factor for bruxism.

Our study results suggest that the prevalence of TMD symptoms is related to increasing frequency of alcohol consumption, and regular consumption of alcohol is significantly associated with TMD symptoms. The association between alcohol consumption and TMD has been investigated in only few studies (Benoliel et al., 2011; Rintakoski & Kaprio, 2013). Rintakoski & Kaprio (2013) found that increasing alcohol intake raised the risk for weekly bruxism even when adjusted for smoking status. They found that heavy drinking, binge drinking and passing out due to excessive alcohol intoxication at least twice within the previous year were associated with bruxism. It can be assumed that the association found between psychoactive substances such as alcohol, tobacco and snuff may be mediated through bruxism. In addition, bruxism has been shown to be associated with disorders of the dopaminergic system (Lavigne et al., 2001; Rintakoski, Ahlberg, Hublin, Broms et al., 2010; Rintakoski, Ahlberg, Hublin, Lobbezoo et. al., 2010). Psychoactive substances affect the nervous system and cause changes in the neurotransmitters or their receptors. Nonetheless, there is no evidence of a clear mechanism that would explain the association between alcohol use, TMD, and bruxism.

It is known that frequent smoking and alcohol consumption have a connection with unhealthy lifestyle *per se* (Huttunen et al., 2022; Tanner et al., 2014), and smoking is known to associate positively with alcohol consumption (De Leon et al., 2007; Madden, 2002). It can be assumed that unhealthy lifestyle as a whole may be an important factor in provoking the TMD symptoms. This creates a demand for further studies.

6.5 Physical activity and fitness

According to our study, low self-reported physical activity and poor physical fitness associated especially with pain-related TMD symptoms. In addition, all TMD symptoms were associated with low physical activity, and especially with reported low current activity. It is remarkable that TMJ pain on jaw opening had the weakest association with physical fitness and activity. It can be assumed that those symptoms are related to TMJ pathology rather than general pain mechanisms as regards facial pain. There is no simple explanation for the association, but it may occur through different ways. Psychosocial factors may associate with both physical activity (Kapsal et al., 2019) and pain experience, and central sensitization (Suvinen et al., 2005). Psychosocial factors were not assessed in this study, and additional studies are needed to evaluate their potential role.

Furthermore, insufficient sleep may affect pain experience and decrease physical activity (Okifuji et al., 2011). In addition, the association between chronic pain and low physical activity may be explained by neurobiological mechanisms, and possibly, by the link with the dopaminergic system (Senba et al., 2017).

An interesting finding of the present study was that poor push-up results associated significantly with nearly all TMD symptoms while the other tests varied in their associations. Overall, poor results in most of the fitness tests (except standing long jump) seemed to associate with TMD pain symptoms, except for difficulties in mouth opening, which is a less frequent condition and refers more to TMJ pathology. The neck and shoulder muscles are functionally linked with the masticatory system (Häggman-Henrikson et al., 2018; Okifuji & Hare, 2011), and their exercise may have a protective effect against TMD symptoms, which could be an explanation for the results. Wänman (2011) found that the majority of TMD patients had frequent pain in the shoulder, cervical and low back regions. In addition, other studies have shown high co-morbidity between pain in other sites and TMD (Fillingim et al., 2018; Maixner et al., 2016), and it is most likely that they share a common underlying mechanism.

6.5.1 BMI and TMD symptoms

The present study showed that high body mass index (BMI) associated with pain-related TMD symptoms and that the effect of BMI remained significant in the multivariate analysis, meaning that BMI has an independent effect. BMI is commonly used to measure overweight and obesity in large population-based studies, but it is not a golden standard to measure the amount of body fat. Studies concerning the association between obesity and TMD are still limited, and they show partly contradictory results, as does the present study. Rhim et al. (2016) found that TMD was associated with decreased BMI and abdominal obesity in women while males did not show any significant association between BMI and TMD, based on a study from adult Korean population. Another study, by Jordani et al. (2019), also found that obesity did not associate with the presence of TMD pain in adolescents.

Obesity and overweight can cause low-grade inflammation (Eklund, 2009) (CRP < 10 mg/L), and this can be related to chronic TMD (Banafa et al., 2019). On the other hand, it can be speculated that psychosocial factors may be a potential link between high BMI and TMD symptoms. This association was not investigated here, and further studies are needed to clarify this connection.

6.6 OHRQoL and psychosocial factors

The results of this study confirmed that the psychosocial subscales of the RDC/TMD Axis II associate with OHRQoL so that OHRQoL mostly worsens as symptoms increase. This study showed that the TMD patient group had significantly poorer OHRQoL than the non-patient group; the OHIP prevalence was almost 3 times higher in the patient group. This highlights the significance of TMD in impairing OHRQoL. An interesting finding was that the patient group showed much higher OHIP prevalence and OHIP severity points on all Axis II subscales, but statistically significant differences were seen especially in the non-patient group on all Axis II subscales.

The results of another study support the role of psychosocial factors in the background of TMD. The association of TMD symptoms with psychosocial factors has been evaluated in many studies (Suvinen et al., 2005). Rantala et al. (2003, 2004) found a significant relationship between somatization and myofascial pain. There is also significant evidence suggesting that psychosocial factors are fundamental in the understanding of TMD and its symptoms and other chronic pain disorders as well (LeResche, 1997; Okeson, 2019; Sipilä et al., 2001; Sójka et al., 2019). In addition, psychosocial factors are significantly related to other musculoskeletal pain conditions, such as neck pain (Ariëns, Bongers et al., 2001, Ariëns, van Mechelen et al., 2001; Linton, 2000). This underlines the complex relationship between pain and psychosocial factors in both patients and non-patients.

In this study, the non-patient group consisted of dental students, and they are supposed to experience more stress and depression than the working adult population (Niskanen et al., 2021). The levels of somatization and depression symptoms were considerably high in the non-patient group, being higher than those in a Finnish working population in the study of Rantala et al. (2004). Sojka et al. (2019) showed the relationship between psychosocial factors and TMD in a medical student population. They found that there is a negative relationship between a sense of coherence and the level of perceived distress, anxiety, somatization, and depression. In addition, they found that female students attending medical school showed a higher level of somatization of stress but with a higher capacity to overcome challenges as compared to men. It can also be speculated that students experience more stress and depression but that dental students have more awareness of TMD symptoms, and this may affect their report of symptoms. In addition, in this study we used reference values as suggested in the RDC/TMD (Dworkin & LeResche, 1992), whereas in the other Finnish study (Rantala et al., 2003) the population was divided into three groups by percentiles to assess depression.

6.7 Strengths and limitations

6.7.1 Studies I and II:

The strengths of this study were especially the versatile methodology and large sample size; to our knowledge, similar studies concerning TMD have not been conducted. Physical fitness was determined with four different physical tests (Cooper test, push-ups, sit-ups and standing long jump) representing different types of fitness. Cooper test represents aerobic fitness while the other tests are more representative of anaerobic muscular fitness. In the present study, instead of using continuous variables, physical test results were classified, based on the cut-offs for the physical test were based on the Finnish Defense Force instructions (Pihlainen et al., 2011) and on international standards (Cooper, 1968; Fletcher et al., 1992). In addition, background information was collected with questionnaires. Other background information and BMI values were achieved from patient register (Mildoc, Defense Forces database).

A weakness and limitation of the present study is that the data of TMD symptoms were based on self-reported questions due to the lack of time and personnel resources for a sample of this size. These questions are not validated to assess TMD but have been used previously in other large population-based studies (Rauhala et al., 2000). Validated questions for screening TMD symptoms have later been developed (Nilsson et al., 2006). Thus, the reported pain symptoms did not necessarily only represent TMD symptoms; other possible causes may include dental pathologies and infections related to erupting wisdom teeth, for example. However, the Northern Finland Birth Cohort 1966 study also found that facial pain based on these questions associated strongly with clinically assessed TMD (Sipilä et al., 2002). It should be noted that besides the variables used in the multivariate models, there may be other possible variables that were not considered in the present study. For example, poor sleep may associate with TMD pain (Vierola et al., 2017) and physical activity (Hartescu et al., 2015).

This cross-sectional study did not allow any estimates about causal relationships. The dichotomic division may cause underestimation in the physical active group; the option “now and then” for the last 6 months of physical activity suggests occasional but not regular activity while the next answer option “almost every day” suggests activity more than 3 times a week. This problem in dichotomization may also concern the physical tests.

6.7.2 Study III:

The use of a valid and standardized instrument for the assessment of OHRQoL and RDC/TMD Axis II instruments was a strength of the study. To evaluate the association in both TMD patients and the general population, we used to different groups, TMD patients and non-patients. A weakness in this study was that the mean ages of the subjects in the TMD patients (43.5 years) and non-patient groups (25.3 years) were not coherent. The gender distribution was also not completely equal between the groups, as the non-patient group included higher percentages of men than the patient group. The low sample size may have caused the relatively wide confidence intervals.

7 Clinical implications and future perspectives

The present study emphasizes the role of health behaviors in the appearance of TMD symptoms. There is a distinct association between the use of psychoactive substances, physical activity and fitness, overweight and TMD symptoms. TMD also associates with OHRQoL through depression and somatization. All these should be considered in the anamnesis and planning of treatment of TMD patients, and even in the prevention of TMD symptoms.

According to this study, future studies should provide answers and further evidence for:

- the role of psychosocial factors as a link between lifestyle factors, BMI and TMD symptoms
- the mechanism by which psychoactive substances (smoking and alcohol) affect TMD
- how to provide instruments to detect TMD risk patients from general population
- clinical follow-up studies concerning the role of physical activity/fitness in TMD

8 Conclusion

In conclusion, the prevalence of TMD symptoms is relatively high among generally healthy young adults, the prevalence of most of the symptoms being higher among women than men. Self-reported TMD symptoms varied between 5.8% and 27.8%. The most significant health behavior factors associating with TMD symptoms were heavy smoking (20 cigarettes or more a day) and increasing frequency and regular consumption of alcohol. Poor physical fitness, low self-reported physical activity, and high BMI associated especially with pain-related TMD symptoms. This study provides new valuable information on the role of the use of psychoactive substances and physical fitness in TMD. These factors should be taken into consideration to prevent TMD symptoms and in the treatment of TMD patients.

In addition, the findings of the present study support some previous studies concerning the role of psychosocial aspects for TMD symptoms. Pain-related disability and depression/somatization symptoms associate with OHRQoL. OHRQoL mostly worsens as these symptoms increase. TMD patients have poorer OHRQoL than non-patients. TMD associates with OHRQoL by multiple ways, especially through psychosocial factors. These should be evaluated and considered in order to achieve effective and appropriate treatment of TMD.

References

Al-Jundi, M. A., John, M. T., Setz, J. M., Szentpétery, A., & Kuss, O. (2008). Meta-analysis of treatment need for temporomandibular disorders in adult nonpatients. *Journal of Orofacial Pain, 22*(2), 97–107.

Anderson, G. C., Gonzalez, Y. M., Ohrbach, R., Truelove, E. L., Sommers, E., Look, J. O., & Schiffman, E. L. (2010). The Research Diagnostic Criteria for Temporomandibular Disorders. VI: future directions. *Journal of Orofacial Pain, 24*(1), 79–88.

Anttonen, V., Kämppi, A., Päkkilä, J., Patinen, P., Tanner, T., & Tjäderhane, L. (2012). A methodological pilot study on oral health of young, healthy males. *Dental Hypotheses, 3*(3), 106–111. https://www.dentalhypotheses.com/text.asp?2012/3/3/106/103928. https://doi.org/10.4103/2155-8213.103928

Ariëns, G. A., Bongers, P. M., Hoogendoorn, W. E., Houtman, I. L., van der Wal, G., & van Mechelen, W. (2001). High quantitative job demands and low coworker support as risk factors for neck pain: results of a prospective cohort study. *Spine, 26*(17), 1896–1903. https://doi.org/10.1097/00007632-200109010-00016

Ariëns, G. A., van Mechelen, W., Bongers, P. M., Bouter, L. M., & van der Wal, G. (2001). Psychosocial risk factors for neck pain: a systematic review. *American Journal of Industrial Medicine, 39*(2), 180–193. https://doi.org/10.1002/1097-0274(200102)39:2<180::aid-ajim1005>3.0.co;2-#

Auvinen, J., Tammelin, T., Taimela, S., Zitting, P., & Karppinen, J. (2008). Associations of physical activity and inactivity with low back pain in adolescents. *Scandinavian Journal of Medicine & Science in Sports, 18*(2), 188–194. https://doi.org/10.1111/j.1600-0838.2007.00672.x

Bäck, K., Hakeberg, M., Wide, U., Hange, D., & Dahlström, L. (2020). Orofacial pain and its relationship with oral health-related quality of life and psychological distress in middle-aged women. *Acta Odontologica Scandinavica, 78*(1), 74–80. https://doi.org/10.1080/00016357.2019.1661512

Bair, E., Brownstein, N. C., Ohrbach, R., Greenspan, J. D., Dubner, R., Fillingim, R. B., Maixner, W., Smith, S. B., Diatchenko, L., Gonzalez, Y., Gordon, S. M., Lim, P. F., Ribeiro-Dasilva, M., Dampier, D., Knott, C., & Slade, G. D. (2013). Study protocol, sample characteristics, and loss to follow-up: the OPPERA prospective cohort study. *The Journal of Pain, 14*(12 Suppl), T2–T19. https://doi.org/10.1016/j.jpain.2013.06.006

Bair, E., Gaynor, S., Slade, G. D., Ohrbach, R., Fillingim, R. B., Greenspan, J. D., Dubner, R., Smith, S. B., Diatchenko, L., & Maixner, W. (2016). Identification of clusters of individuals relevant to temporomandibular disorders and other chronic pain conditions: the OPPERA study. *Pain, 157*(6), 1266–1278. https://doi.org/10.1097/j.pain.0000000000000518

Banafa, A., Suominen, A. L., & Sipilä, K. (2020). Factors associated with signs of temporomandibular pain: an 11-year-follow-up study on Finnish adults. *Acta Odontologica Scandinavica, 78*(1), 57–63. https://doi.org/10.1080/00016357.2019.1650955

Baune, B. T., Caniato, R. N., Garcia-Alcaraz, M. A., & Berger, K. (2008). Combined effects of major depression, pain and somatic disorders on general functioning in the general adult population. *Pain, 138*(2), 310–317. https://doi.org/10.1016/j.pain.2008.01.002

Bayat, M., Abbasi, A. J., Noorbala, A. A., Mohebbi, S. Z., Moharrami, M., & Yekaninejad, M. S. (2018). Oral health-related quality of life in patients with temporomandibular disorders: A case-control study considering psychological aspects. *International Journal of Dental Hygiene, 16*(1), 165–170. https://doi.org/10.1111/idh.12266

Benoliel, R., Sela, G., Teich, S., & Sharav, Y. (2011). Painful temporomandibular disorders and headaches in 359 dental and medical students. *Quintessence International (Berlin, Germany : 1985), 42*(1), 73–78.

Bueno, C. H., Pereira, D. D., Pattussi, M. P., Grossi, P. K., & Grossi, M. L. (2018). Gender differences in temporomandibular disorders in adult populational studies: A systematic review and meta-analysis. *Journal of Oral Rehabilitation, 45*(9), 720–729. https://doi.org/10.1111/joor.12661

Cao, Y., Yap, A. U., Lei, J., Zhang, M. J., & Fu, K. Y. (2022). Oral health-related quality of life of patients with acute and chronic temporomandibular disorder diagnostic subtypes. *Journal of the American Dental Association (1939), 153*(1), 50–58. https://doi.org/10.1016/j.adaj.2021.07.011

Chen, H., Nackley, A., Miller, V., Diatchenko, L., & Maixner, W. (2013). Multisystem dysregulation in painful temporomandibular disorders. *The Journal of Pain, 14*(9), 983–996. https://doi.org/10.1016/j.jpain.2013.03.011

Cho, H. J., Kim, S. J., Park, S. E., & Park, J. W. (2020). Physical activity level and temporomandibular disorders in South Koreans. *Community Dentistry and Oral Epidemiology, 48*(3), 225–231. https://doi.org/10.1111/cdoe.12519

Christidis, N., Lindström Ndanshau, E., Sandberg, A., & Tsilingaridis, G. (2019). Prevalence and treatment strategies regarding temporomandibular disorders in children and adolescents-A systematic review. *Journal of Oral Rehabilitation, 46*(3), 291–301. https://doi.org/10.1111/joor.12759

Conscription Act 28.12.2007/1438.

Cooper K. H. (1968). A means of assessing maximal oxygen intake. Correlation between field and treadmill testing. *JAMA, 203*(3), 201–204.

Custodio, L., Carlson, C. R., Upton, B., Okeson, J. P., Harrison, A. L., & de Leeuw, R. (2015). The impact of cigarette smoking on sleep quality of patients with masticatory myofascial pain. *Journal of Oral & Facial Pain and Headache, 29*(1), 15–23. https://doi.org/10.11607/ofph.1266

de Leeuw, R., Eisenlohr-Moul, T., & Bertrand, P. (2013). The association of smoking status with sleep disturbance, psychological functioning, and pain severity in patients with temporomandibular disorders. *Journal of Orofacial Pain, 27*(1), 32–41. https://doi.org/10.11607/jop.1040

de Leeuw, R., & Klasser, G. D. (2018). *Orofacial Pain: Guidelines for Assessment, Diagnosis, and Management*. 6th edition. Chicago, Illinois: Quintessence Publishing.

De Leon, J., Rendon, D. M., Baca-Garcia, E., Aizpuru, F., Gonzalez-Pinto, A., Anitua, C., & Diaz, F. J. (2007). Association between smoking and alcohol use in the general population: stable and unstable odds ratios across two years in two different countries. *Alcohol and Alcoholism (Oxford, Oxfordshire), 42*(3), 252–257. https://doi.org/10.1093/alcalc/agm029

Derogatis, L. R. (1994). Symptom Checklist-90-R: Administration, scoring & procedure manual for the revised version of the SCL-90. Minneapolis, MN: National Computer Systems.

Dohrenwend, B. P., Raphael, K. G., Marbach, J. J., & Gallagher, R. M. (1999). Why is depression comorbid with chronic myofascial face pain? A family study test of alternative hypotheses. *Pain, 83*(2), 183–192. https://doi.org/10.1016/s0304-3959(99)00100-1

Dworkin, S. F. (1995). Behavioral characteristics of chronic temporomandibular disorders: Diagnosis and assessment. Kirjassa: Sessle BJ, Bryant PS, Dionne RA (toim.) Temporomandibular disorders and related pain conditions. Progress in pain research and management. Munksgaard, Copenhagen 4. painos. 1995:175-92

Dworkin, S. F., & LeResche, L. (1992). Research diagnostic criteria for temporomandibular disorders: review, criteria, examinations and specifications, critique. *Journal of Craniomandibular Disorders : Facial & Oral Pain, 6*(4), 301–355.

Dworkin, S. F., Huggins, K. H., LeResche, L., Von Korff, M., Howard, J., Truelove, E., & Sommers, E. (1990). Epidemiology of signs and symptoms in temporomandibular disorders: clinical signs in cases and controls. *Journal of the American Dental Association (1939), 120*(3), 273–281. https://doi.org/10.14219/jada.archive.1990.0043

Dworkin, S. F., Sherman, J., Mancl, L., Ohrbach, R., LeResche, L., & Truelove, E. (2002). Reliability, validity, and clinical utility of the research diagnostic criteria for Temporomandibular Disorders Axis II Scales: depression, non-specific physical symptoms, and graded chronic pain. *Journal of Orofacial Pain, 16*(3), 207–220.

Eklund C. M. (2009). Proinflammatory cytokines in CRP baseline regulation. *Advances in clinical chemistry*, 48, 111–136. https://doi.org/10.1016/s0065-2423(09)48005-3

Fillingim, R. B., Ohrbach, R., Greenspan, J. D., Knott, C., Diatchenko, L., Dubner, R., Bair, E., Baraian, C., Mack, N., Slade, G. D., & Maixner, W. (2013). Psychological factors associated with development of TMD: the OPPERA prospective cohort study. *The Journal of Pain, 14*(12 Suppl), T75–T90. https://doi.org/10.1016/j.jpain.2013.06.009

Fletcher, G. F., Blair, S. N., Blumenthal, J., Caspersen, C., Chaitman, B., Epstein, S., Falls, H., Froelicher, E. S., Froelicher, V. F., & Pina, I. L. (1992). Statement on exercise. Benefits and recommendations for physical activity programs for all Americans. A statement for health professionals by the Committee on Exercise and Cardiac Rehabilitation of the Council on Clinical Cardiology, American Heart association. *Circulation, 86*(1), 340–344. https://doi.org/10.1161/01.cir.86.1.340

Gillborg, S., Åkerman, S., Lundegren, N., & Ekberg, E. C. (2017). Temporomandibular Disorder Pain and Related Factors in an Adult Population: A Cross-Sectional Study in Southern Sweden. *Journal of Oral & Facial Pain and Headache, 31*(1), 37–45. https://doi.org/10.11607/ofph.1517

Greenspan, J. D., Slade, G. D., Bair, E., Dubner, R., Fillingim, R. B., Ohrbach, R., Knott, C., Diatchenko, L., Liu, Q., & Maixner, W. (2013). Pain sensitivity and autonomic factors associated with development of TMD: the OPPERA prospective cohort study. *The Journal of Pain, 14*(12 Suppl), T63–74.e746. https://doi.org/10.1016/j.jpain.2013.06.007

Häggman-Henrikson, B., Wiesinger, B., & Wänman, A. (2018). The effect of supervised exercise on localized TMD pain and TMD pain associated with generalized pain. *Acta odontologica Scandinavica*, 76(1), 6–12. https://doi.org/10.1080/00016357.2017.1373304

Hartescu, I., Morgan, K., & Stevinson, C. D. (2015). Increased physical activity improves sleep and mood outcomes in inactive people with insomnia: a randomized controlled trial. *Journal of Sleep Research, 24*(5), 526–534. https://doi.org/10.1111/jsr.12297

Helkimo M. (1974). Studies on function and dysfunction of the masticatory system. II. Index for anamnestic and clinical dysfunction and occlusal state. *Svensk Tandlakare Tidskrift. Swedish Dental Journal, 67*(2), 101–121.

Hietaharju, M., Kivimäki, I., Heikkilä, H., Näpänkangas, R., Teerijoki-Oksa, T., Tanner, J., Kemppainen, P., Tolvanen, M., Suvinen, T., & Sipilä, K. (2021). Comparison of Axis II psychosocial assessment methods of RDC/TMD and DC/TMD as part of DC/TMD-FIN phase II validation studies in tertiary care Finnish TMD pain patients. *Journal of Oral Rehabilitation, 48*(12), 1295–1306. https://doi.org/10.1111/joor.13260

Hiltunen, K., Peltola, J. S., Vehkalahti, M. M., Närhi, T., & Ainamo, A. (2003). A 5-year follow-up of signs and symptoms of TMD and radiographic findings in the elderly. *The International Journal of Prosthodontics, 16*(6), 631–634.

Hirsch, C., & Türp, J. C. (2010). Temporomandibular pain and depression in adolescents--a case-control study. *Clinical Oral Investigations, 14*(2), 145–151. https://doi.org/10.1007/s00784-009-0265-5

Huhtela, O. S., Näpänkangas, R., Joensuu, T., Raustia, A., Kunttu, K., & Sipilä, K. (2016). Self-Reported Bruxism and Symptoms of Temporomandibular Disorders in Finnish University Students. *Journal of Oral & Facial Pain and Headache, 30*(4), 311–317. https://doi.org/10.11607/ofph.1674

Huhtela, O. S., Näpänkangas, R., Suominen, A. L., Karppinen, J., Kunttu, K., & Sipilä, K. (2021). Association of psychological distress and widespread pain with sympatoms of temporomandibular disorders and self-reported bruxism in students. *Clinical and Experimental Dental Research, 7*(6), 1154–1166. https://doi.org/10.1002/cre2.472

Huttunen, M., Kämppi, A., Soudunsaari, A., Päkkilä, J., Tjäderhane, L., Laitala, M. L., Anttonen, V., Patinen, P., & Tanner, T. (2022). The association between dental caries and physical activity, physical fitness, and background factors among Finnish male conscripts. *Odontology*, 10.1007/s10266-022-00717-5. Advance online publication. https://doi.org/10.1007/s10266-022-00717-5

Ivković, N., Racic, M., Lecic, R., Bozovic, D., & Kulic, M. (2018). Relationship Between Symptoms of Temporomandibular Disorders and Estrogen Levels in Women With Different Menstrual Status. *Journal of Oral & Facial Pain and Headache, 32*(2), 151–158. Advance online publication. https://doi.org/10.11607/ofph.1906

Johansson, A., Unell, L., Carlsson, G. E., Söderfeldt, B., & Halling, A. (2003). Gender difference in symptoms related to temporomandibular disorders in a population of 50-year-old subjects. *Journal of Orofacial Pain, 17*(1), 29–35.

Johansson, A., Unell, L., Carlsson, G., Söderfeldt, B., Halling, A., & Widar, F. (2004). Associations between social and general health factors and symptoms related to temporomandibular disorders and bruxism in a population of 50-year-old subjects. *Acta Odontologica Scandinavica, 62*(4), 231–237. https://doi.org/10.1080/00016350410001649

John, M. T., Reissmann, D. R., Schierz, O., & Wassell, R. W. (2007). Oral health-related quality of life in patients with temporomandibular disorders. *Journal of Orofacial Pain, 21*(1), 46–54.

Jordani, P. C., Campi, L. B., Braido, G. V. V., Fernandes, G., Visscher, C. M., & Gonçalves, D. A. G. (2019). Obesity, sedentarism and TMD-pain in adolescents. *Journal of Oral Rehabilitation, 46*(5), 460–467. https://doi.org/10.1111/joor.12771

Jussila, P., Kiviahde, H., Näpänkangas, R., Päkkilä, J., Pesonen, P., Sipilä, K., Pirttiniemi, P., & Raustia, A. (2017). Prevalence of Temporomandibular Disorders in the Northern Finland Birth Cohort 1966. *Journal of Oral & Facial Pain and Headache, 31*(2), 159–164. https://doi.org/10.11607/ofph.1773

Kämppi, A., Päkkilä, J., Tanner, T., Patinen, P., Tjäderhane, L., & Anttonen, V. (2014). Validity of a questionnaire in estimating restorative treatment need among young adults. *Community Dental Health, 31*(4), 245–250.

Kämppi, A., Tanner, T., Päkkilä, J., Patinen, P., Järvelin, M. R., Tjäderhane, L., & Anttonen, V. (2013). Geographical distribution of dental caries prevalence and associated factors in young adults in Finland. *Caries Research, 47*(4), 346–354. https://doi.org/10.1159/000346435

Kämppi, A., Tanner, T., Päkkilä, J., Patinen, P., Tjäderhane, L., & Anttonen, V. (2016). Comparison of simple screening criteria with the International Caries Detection and Assessment System classification in determining restorative treatment need. *International Dental Journal, 66*(2), 63–70. https://doi.org/10.1111/idj.12204

Kapsal, N. J., Dicke, T., Morin, A. J. S., Vasconcellos, D., Maïano, C., Lee, J., & Lonsdale, C. (2019). Effects of Physical Activity on the Physical and Psychosocial Health of Youth With Intellectual Disabilities: A Systematic Review and Meta-Analysis. *Journal of Physical Activity & Health, 16*(12), 1187–1195. https://doi.org/10.1123/jpah.2018-0675

Kinnunen, J., Pere, L., Raisamo, S., Katainen, A., Myöhänen, A., Lahti, L., Ahtinen, S., Ollila, H., Lindfors, P., & Rimpelä, A. (2019). *The Adolescent Health and Lifestyel Survey 2019: Adolescent Tobacco and Alcohol Use and Gambling*. (In Finnish, abstract in English). Helsinki. Ministry of Soccial Affairs and Health, 2019:56. http//um.fi/URN:ISBN:978-952-00-4105-2. Accessed 6 October 2022.

Köhler, A. A., Helkimo, A. N., Magnusson, T., & Hugoson, A. (2009). Prevalence of symptoms and signs indicative of temporomandibular disorders in children and adolescents. A cross-sectional epidemiological investigation covering two decades. *European Archives of Paediatric Dentistry : Official Journal of the European Academy of Paediatric Dentistry, 10 Suppl 1*, 16–25. https://doi.org/10.1007/BF03262695

Köhler, A. A., Hugoson, A., & Magnusson, T. (2012). Prevalence of symptoms indicative of temporomandibular disorders in adults: cross-sectional epidemiological investigations covering two decades. *Acta Odontologica Scandinavica, 70*(3), 213–223. https://doi.org/10.3109/00016357.2011.634832

Könönen, M., Waltimo, A., & Nyström, M. (1996). Does clicking in adolescence lead to painful temporomandibular joint locking?. *Lancet (London, England), 347*(9008), 1080–1081. https://doi.org/10.1016/s0140-6736(96)90280-9

Kronström, K., Multimäki, P., Ristkari, T., Parkkola, K., Sillanmäki, L., & Sourander, A. (2021). Ten-year changes in the psychosocial well-being, psychopathology, substance use, suicidality, bullying, and sense of coherence of 18-year-old males: a Finnish population-based time-trend study. *European Child & Adolescent Psychiatry, 30*(2), 313–325. https://doi.org/10.1007/s00787-020-01517-4

Kuttila, M., Niemi, P. M., Kuttila, S., Alanen, P., & Le Bell, Y. (1998). TMD treatment need in relation to age, gender, stress, and diagnostic subgroup. *Journal of Orofacial Pain, 12*(1), 67–74.

Lahti, S., Suominen-Taipale, L., & Hausen, H. (2008). Oral health impacts among adults in Finland: competing effects of age, number of teeth, and removable dentures. *European Journal of Oral Sciences, 116*(3), 260–266. https://doi.org/10.1111/j.1600-0722.2008.00540.x

LaRowe, L. R., & Ditre, J. W. (2020). Pain, nicotine, and tobacco smoking: current state of the science. *Pain, 161*(8), 1688–1693. https://doi.org/10.1097/j.pain.0000000000001874

Lavigne, G. J., Soucy, J. P., Lobbezoo, F., Manzini, C., Blanchet, P. J., & Montplaisir, J. Y. (2001). Double-blind, crossover, placebo-controlled trial of bromocriptine in patients with sleep bruxism. *Clinical Neuropharmacology, 24*(3), 145–149. https://doi.org/10.1097/00002826-200105000-00005

Lehesjoki, M. (2018). Varusmiespalveluksen varhainen keskeytyminen terveydellisistä syistä. Helsinki. National Defence University. Series 1: Research publications no. 27. Doctoral dissertation (in Finnish, abstract in English).

LeResche L. (1997). Epidemiology of temporomandibular disorders: implications for the investigation of etiologic factors. *Critical Reviews in Oral Biology and Medicine : An Official Publication of the American Association of Oral Biologists, 8*(3), 291–305. https://doi.org/10.1177/10454411970080030401

Linton, S. J. (2000). A review of psychological risk factors in back and neck pain. *Spine, 25*(9), 1148–1156. https://doi.org/10.1097/00007632-200005010-00017

List, T., Wahlund, K., Wenneberg, B., & Dworkin, S. F. (1999). TMD in children and adolescents: prevalence of pain, gender differences, and perceived treatment need. *Journal of Orofacial Pain, 13*(1), 9–20.

Locker, D., & Allen, F. (2007). What do measures of 'oral health-related quality of life' measure?. *Community Dentistry and Oral Epidemiology, 35*(6), 401–411. https://doi.org/10.1111/j.1600-0528.2007.00418.x

Lövgren, A., Häggman-Henrikson, B., Visscher, C. M., Lobbezoo, F., Marklund, S., & Wänman, A. (2016). Temporomandibular pain and jaw dysfunction at different ages covering the lifespan--A population based study. *European Journal Of Pain (London, England), 20*(4), 532–540. https://doi.org/10.1002/ejp.755

Lövgren, A., Parvaneh, H., Lobbezoo, F., Häggman-Henrikson, B., Wänman, A., & Visscher, C. M. (2018). Diagnostic accuracy of three screening questions (3Q/TMD) in relation to the DC/TMD in a specialized orofacial pain clinic. *Acta Odontologica Scandinavica, 76*(6), 380–386. https://doi.org/10.1080/00016357.2018.1439528

Macfarlane, T. V., Beasley, M., & Macfarlane, G. J. (2014). Self-Reported Facial Pain in UK Biobank Study: Prevalence and Associated Factors. *Journal of Oral & Maxillofacial Research, 5*(3), e2. https://doi.org/10.5037/jomr.2014.5302

Madden, P. A., & Heath, A. C. (2002). Shared genetic vulnerability in alcohol and cigarette use and dependence. *Alcoholism, Clinical and Experimental Research, 26*(12), 1919–1921. https://doi.org/10.1097/01.ALC.0000040960.15151.30

Magni, G., Moreschi, C., Rigatti-Luchini, S., & Merskey, H. (1994). Prospective study on the relationship between depressive symptoms and chronic musculoskeletal pain. *Pain, 56*(3), 289–297. https://doi.org/10.1016/0304-3959(94)90167-8

Maixner, W., Diatchenko, L., Dubner, R., Fillingim, R. B., Greenspan, J. D., Knott, C., Ohrbach, R., Weir, B., & Slade, G. D. (2011). Orofacial pain prospective evaluation and risk assessment study--the OPPERA study. *The Journal of Pain, 12*(11 Suppl), T4–11.e112. https://doi.org/10.1016/j.jpain.2011.08.002

Maixner, W., Fillingim, R. B., Williams, D. A., Smith, S. B., & Slade, G. D. (2016). Overlapping Chronic Pain Conditions: Implications for Diagnosis and Classification. *The Journal of Pain, 17*(9 Suppl), T93–T107. https://doi.org/10.1016/j.jpain.2016.06.002

Melis, M., Lobo, S. L., Ceneviz, C., Ruparelia, U. N., Zawawi, K. H., Chandwani, B. P., & Mehta, N. R. (2010). Effect of cigarette smoking on pain intensity of TMD patients: a pilot study. *Cranio : The Journal of Craniomandibular Practice, 28*(3), 187–192. https://doi.org/10.1179/crn.2010.026

Nilsson, I. M., List, T., & Drangsholt, M. (2005). Prevalence of temporomandibular pain and subsequent dental treatment in Swedish adolescents. *Journal of Orofacial Pain, 19*(2), 144–150.

Nilsson, I. M., List, T., & Drangsholt, M. (2006). The reliability and validity of self-reported temporomandibular disorder pain in adolescents. *Journal of Orofacial Pain, 20*(2), 138–144.

Niskanen, M., Hietaharju, M., Näpänkangas, R., Suvinen, T., & Sipilä, K. (2021). Psyykkinen kuormittuneisuus ja TMD opiskelijoilla. *Suomen Hammaslääkärilehti 2021, 6*, 24–31. https://www.hammaslaakarilehti.fi/fi/tiede/psyykkinen-kuormittunei-suus-ja-tmd-opiskelijoilla

Oancea, R., Timar, B., Papava, I., Cristina, B. A., Ilie, A. C., & Dehelean, L. (2020). Influence of depression and self-esteem on oral health-related quality of life in students. *The Journal of International Medical Research, 48*(2), 300060520902615. https://doi.org/10.1177/0300060520902615

Oghli, I., List, T., Su, N., & Häggman-Henrikson, B. (2020). The impact of oro-facial pain conditions on oral health-related quality of life: A systematic review. *Journal of Oral Rehabilitation, 47*(8), 1052–1064. https://doi.org/10.1111/joor.12994

Ohrbach, R., Bair, E., Fillingim, R. B., Gonzalez, Y., Gordon, S. M., Lim, P. F., Ribeiro-Dasilva, M., Diatchenko, L., Dubner, R., Greenspan, J. D., Knott, C., Maixner, W., Smith, S. B., & Slade, G. D. (2013). Clinical orofacial characteristics associated with risk of first-onset TMD: the OPPERA prospective cohort study. *The Journal of Pain, 14*(12 Suppl), T33–T50. https://doi.org/10.1016/j.jpain.2013.07.018

Okeson, J. P. (2019). *Management of Temporomandibular Disorders and Occlusion, 8th ed.*; Elsevier: Amsterdam, The Netherlands, 2019; pp. 102–128

Okifuji, A., & Hare, B. D. (2011). Do sleep disorders contribute to pain sensitivity?. *Current Rheumatology Reports, 13*(6), 528–534. https://doi.org/10.1007/s11926-011-0204-8

Osterberg, T., & Carlsson, G. E. (2007). Relationship between symptoms of temporomandibular disorders and dental status, general health and psychosomatic factors in two cohorts of 70-year-old subjects. *Gerodontology, 24*(3), 129–135. https://doi.org/10.1111/j.1741-2358.2007.00162.x

Park, J., Jung, E., & Bae, E. (2021). Differences in problem alcohol drinking by military service type among male professional military personnel in South Korea using Military Health Survey data. *BMJ open, 11*(11), e045279. https://doi.org/10.1136/bmjopen-2020-045279

Pihlainen, K., Ohrankämmen, O., & Ilomäki, J. (2011). Puolustusvoimien Kuntotestaajan Käsikirja, 2nd ed.; Edita Prima: Helsinki, Finland, 2011.

Qvintus, V., Sipilä, K., Le Bell, Y., & Suominen, A. L. (2020). Prevalence of clinical signs and pain symptoms of temporomandibular disorders and associated factors in adult Finns. *Acta Odontologica Scandinavica, 78*(7), 515–521. https://doi.org/10.1080/00016357.2020.1746395

Qvintus, V., Suominen, A. L., Huttunen, J., Raustia, A., Ylöstalo, P., & Sipilä, K. (2015). Efficacy of stabilisation splint treatment on facial pain - 1-year follow-up. *Journal of Oral Rehabilitation, 42*(6), 439–446. https://doi.org/10.1111/joor.12275

Rantala, M. A., Ahlberg, J., Suvinen, T. I., Savolainen, A., & Könönen, M. (2003). Symptoms, signs, and clinical diagnoses according to the research diagnostic criteria for temporomandibular disorders among Finnish multiprofessional media personnel. *Journal of Orofacial Pain, 17*(4), 311–316.

Rauhala, K., Oikarinen, K. S., Järvelin, M. R., & Raustia, A. M. (2000). Facial pain and temporomandibular disorders: an epidemiological study of the Northern Finland 1966 Birth Cohort. *Cranio : The Journal of Craniomandibular Practice, 18*(1), 40–46. https://doi.org/10.1080/08869634.2000.11746112

Reissmann, D. R., John, M. T., Schierz, O., & Wassell, R. W. (2007). Functional and psychosocial impact related to specific temporomandibular disorder diagnoses. *Journal of Dentistry, 35*(8), 643–650. https://doi.org/10.1016/j.jdent.2007.04.010

Rhim, E., Han, K., & Yun, K. I. (2016). Association between temporomandibular disorders and obesity. *Journal of Cranio-Maxillo-Facial Surgery : Official Publication of the European Association for Cranio-Maxillo-Facial Surgery, 44*(8), 1003–1007. https://doi.org/10.1016/j.jcms.2016.04.016

Ribeiro-Dasilva, M. C., Fillingim, R. B., & Wallet, S. M. (2017). Estrogen-Induced Monocytic Response Correlates with TMD Pain: A Case Control Study. *Journal of Dental Research, 96*(3), 285–291. https://doi.org/10.1177/0022034516678599

Rintakoski, K., & Kaprio, J. (2013). Legal psychoactive substances as risk factors for sleep-related bruxism: a nationwide Finnish Twin Cohort study. *Alcohol and Alcoholism (Oxford, Oxfordshire), 48*(4), 487–494. https://doi.org/10.1093/alcalc/agt016

Rintakoski, K., Ahlberg, J., Hublin, C., Broms, U., Madden, P. A., Könönen, M., Koskenvuo, M., Lobbezoo, F., & Kaprio, J. (2010). Bruxism is associated with nicotine dependence: a nationwide Finnish twin cohort study. *Nicotine & Tobacco Research : Official Journal of the Society for Research on Nicotine and Tobacco, 12*(12), 1254–1260. https://doi.org/10.1093/ntr/ntq190

Rintakoski, K., Ahlberg, J., Hublin, C., Lobbezoo, F., Rose, R. J., Murtomaa, H., & Kaprio, J. (2010). Tobacco use and reported bruxism in young adults: a nationwide Finnish Twin Cohort Study. *Nicotine & Tobacco Research : Official Journal of the Society for Research on Nicotine and Tobacco, 12*(6), 679–683. https://doi.org/10.1093/ntr/ntq066

Rutkiewicz, T., Könönen, M., Suominen-Taipale, L., Nordblad, A., & Alanen, P. (2006). Occurrence of clinical signs of temporomandibular disorders in adult Finns. *Journal of Orofacial Pain, 20*(3), 208–217.

Sanders, A. E., Maixner, W., Nackley, A. G., Diatchenko, L., By, K., Miller, V. E., & Slade, G. D. (2012). Excess risk of temporomandibular disorder associated with cigarette smoking in young adults. *The Journal of Pain, 13*(1), 21–31. https://doi.org/10.1016/j.jpain.2011.08.003

Santtila, M., Pihlainen, K., Koski, H., Vasankari, T., & Kyröläinen, H. (2018). Physical Fitness in Young Men between 1975 and 2015 with a Focus on the Years 2005-2015. *Medicine and science in sports and exercise*, 50(2), 292–298. https://doi.org/10.1249/MSS.0000000000001436

Schiffman, E. L., Truelove, E. L., Ohrbach, R., Anderson, G. C., John, M. T., List, T., & Look, J. O. (2010). The Research Diagnostic Criteria for Temporomandibular Disorders. I: overview and methodology for assessment of validity. *Journal of Orofacial Pain, 24*(1), 7–24.

Schiffman, E., Ohrbach, R., Truelove, E., Look, J., Anderson, G., Goulet, J. P., List, T., Svensson, P., Gonzalez, Y., Lobbezoo, F., Michelotti, A., Brooks, S. L., Ceusters, W., Drangsholt, M., Ettlin, D., Gaul, C., Goldberg, L. J., Haythornthwaite, J. A., Hollender, L., Jensen, R., … Orofacial Pain Special Interest Group, International Association for the Study of Pain (2014). Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) for Clinical and Research Applications: recommendations of the International RDC/TMD Consortium Network* and Orofacial Pain Special Interest Group†. *Journal of Oral & Facial Pain and Headache, 28*(1), 6–27. https://doi.org/10.11607/jop.1151

Selaimen, C. M., Jeronymo, J. C., Brilhante, D. P., & Grossi, M. L. (2006). Sleep and depression as risk indicators for temporomandibular disorders in a cross-cultural perspective: a case-control study. *The International Journal of Prosthodontics, 19*(2), 154–161.

Senba, E., & Kami, K. (2017). A new aspect of chronic pain as a lifestyle-related disease. *Neurobiology of Pain (Cambridge, Mass.), 1*, 6–15. https://doi.org/10.1016/j.ynpai.2017.04.003

Sipilä, K., Mäki, P., Laajala, A., Taanila, A., Joukamaa, M., & Veijola, J. (2013). Association of depressiveness with chronic facial pain: a longitudinal study. *Acta Odontologica Scandinavica, 71*(3-4), 644–649. https://doi.org/10.3109/00016357.2012.704067

Sipilä, K., Veijola, J., Jokelainen, J., Järvelin, M. R., Oikarinen, K. S., Raustia, A. M., & Joukamaa, M. (2001). Association between symptoms of temporomandibular disorders and depression: an epidemiological study of the Northern Finland 1966 Birth Cohort. *Cranio : The Journal of Craniomandibular Practice, 19*(3), 183–187. https://doi.org/10.1080/08869634.2001.11746168

Slade G. D. (1997). Derivation and validation of a short-form oral health impact profile. *Community Dentistry and Oral Epidemiology, 25*(4), 284–290. https://doi.org/10.1111/j.1600-0528.1997.tb00941.x

Slade, G. D., & Spencer, A. J. (1994). Development and evaluation of the Oral Health Impact Profile. *Community Dental Health, 11*(1), 3–11.

Slade, G. D., Ohrbach, R., Greenspan, J. D., Fillingim, R. B., Bair, E., Sanders, A. E., Dubner, R., Diatchenko, L., Meloto, C. B., Smith, S., & Maixner, W. (2016). Painful Temporomandibular Disorder: Decade of Discovery from OPPERA Studies. *Journal of Dental Research, 95*(10), 1084–1092. https://doi.org/10.1177/0022034516653743

Slade, G. D., Sanders, A. E., Bair, E., Brownstein, N., Dampier, D., Knott, C., Fillingim, R., Maixner, W. O., Smith, S., Greenspan, J., Dubner, R., & Ohrbach, R. (2013). Preclinical episodes of orofacial pain symptoms and their association with health care behaviors in the OPPERA prospective cohort study. *Pain, 154*(5), 750–760. https://doi.org/10.1016/j.pain.2013.01.014

Smith, M. T., Wickwire, E. M., Grace, E. G., Edwards, R. R., Buenaver, L. F., Peterson, S., Klick, B., & Haythornthwaite, J. A. (2009). Sleep disorders and their association with laboratory pain sensitivity in temporomandibular joint disorder. *Sleep, 32*(6), 779–790. https://doi.org/10.1093/sleep/32.6.779

Sójka, A., Stelcer, B., Roy, M., Mojs, E., & Pryliński, M. (2019). Is there a relationship between psychological factors and TMD?. *Brain and Behavior, 9*(9), e01360. https://doi.org/10.1002/brb3.1360

Stoll, M. L., Sharpe, T., Beukelman, T., Good, J., Young, D., & Cron, R. Q. (2012). Risk factors for temporomandibular joint arthritis in children with juvenile idiopathic arthritis. *The Journal of Rheumatology, 39*(9), 1880–1887. https://doi.org/10.3899/jrheum.111441

Suvinen T, Rantala M, Ahlberg J, Könönen M. Purentaelimistön kivut ja toimintahäiriöt (TMD). Tieteelliset diagnostiset kriteerit. RDC/TMD_FIN. Version: 2010 www.rdctmdinternational.org. Accessed December 15, 2020

Suvinen, T. I., Reade, P. C., Kemppainen, P., Könönen, M., & Dworkin, S. F. (2005). Review of aetiological concepts of temporomandibular pain disorders: towards a biopsychosocial model for integration of physical disorder factors with psychological and psychosocial illness impact factors. *European Journal of Pain (London, England), 9*(6), 613–633. https://doi.org/10.1016/j.ejpain.2005.01.012

Tanner, T., Kämppi, A., Päkkilä, J., Järvelin, M. R., Patinen, P., Tjäderhane, L., & Anttonen, V. (2014). Association of smoking and snuffing with dental caries occurrence in a young male population in Finland: a cross-sectional study. *Acta Odontologica Scandinavica, 72*(8), 1017–1024. https://doi.org/10.3109/00016357.2014.942877

Tanner, T., Kämppi, A., Päkkilä, J., Patinen, P., Rosberg, J., Karjalainen, K., Järvelin, M. R., Tjäderhane, L., & Anttonen, V. (2013). Prevalence and polarization of dental caries among young, healthy adults: Cross-sectional epidemiological study. *Acta Odontologica Scandinavica, 71*(6), 1436–1442. https://doi.org/10.3109/00016357.2013.767932

Tashiro, A., & Bereiter, D. A. (2020). The effects of estrogen on temporomandibular joint pain as influenced by trigeminal caudalis neurons. *Journal of Oral Science, 62*(2), 150–155. https://doi.org/10.2334/josnusd.19-0405

Tuuliainen, L., Sipilä, K., Mäki, P., Könönen, M., & Suominen, A. L. (2015). Association Between Clinical Signs of Temporomandibular Disorders and Psychological Distress Among an Adult Finnish Population. *Journal of Oral & Facial Pain and Headache, 29*(4), 370–377. https://doi.org/10.11607/ofph.1439

Vaara, J. P., Santtila, M., Vasankari, T., Fogelholm, M., Mäntysaari, M., Pihlainen, K., Vaara, E., & Kyröläinen, H. (2020). Cardiorespiratory and muscular fitness in young adult Finnish men between 2003 and 2015. *Scandinavian Journal of Medicine & Science in Sports, 30*(4), 716–724. https://doi.org/10.1111/sms.13619

Vierola, A., Suominen, A. L., Eloranta, A. M., Lintu, N., Ikävalko, T., Närhi, M., & Lakka, T. A. (2017). Determinants for craniofacial pains in children 6-8 years of age: the PANIC study. *Acta Odontologica Scandinavica, 75*(6), 453–460. https://doi.org/10.1080/00016357.2017.1339908

Vierola, A., Suominen, A. L., Lindi, V., Viitasalo, A., Ikävalko, T., Lintu, N., Väistö, J., Kellokoski, J., Närhi, M., & Lakka, T. A. (2016). 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. *The Journal of Pain, 17*(7), 845–853. https://doi.org/10.1016/j.jpain.2016.03.011

Von Korff, M., Dworkin, S. F., Le Resche, L., & Kruger, A. (1988). An epidemiologic comparison of pain complaints. *Pain, 32*(2), 173–183. https://doi.org/10.1016/0304-3959(88)90066-8

Von Korff, M., Ormel, J., Keefe, F. J., & Dworkin, S. F. (1992). Grading the severity of chronic pain. *Pain, 50*(2), 133–149. https://doi.org/10.1016/0304-3959(92)90154-4

Wänman A. (2005). Temporomandibular disorders among smokers and nonsmokers: a longitudinal cohort study. *Journal of Orofacial Pain, 19*(3), 209–217.

Wänman A. (2012). Endurance to physical strain in patients with temporomandibular disorders: a case-control study. *Acta Odontologica Scandinavica, 70*(6), 455–462. https://doi.org/10.3109/00016357.2011.635599

Yap, A. U., Chen, C., Wong, H. C., Yow, M., & Tan, E. (2021). Temporomandibular disorders in prospective orthodontic patients. *The Angle Orthodontist, 91*(3), 377–383. https://doi.org/10.2319/010720-863.1

Yekkalam, N., & Wänman, A. (2014). Associations between craniomandibular disorders, sociodemographic factors and self-perceived general and oral health in an adult population. *Acta Odontologica Scandinavica, 72*(8), 1054–1065. https://doi.org/10.3109/00016357.2014.949843

Yekkalam, N., & Wänman, A. (2014). Prevalence of signs and symptoms indicative of temporomandibular disorders and headaches in 35-, 50-, 65- and 75-year-olds living in Västerbotten, Sweden. *Acta Odontologica Scandinavica, 72*(6), 458–465. https://doi.org/10.3109/00016357.2013.860620

Original publications

I Miettinen, O., Anttonen, V., Patinen, P., Päkkilä, J., Tjäderhane, L., & Sipilä, K. (2017). Prevalence of Temporomandibular Disorder Symptoms and Their Association with Alcohol and Smoking Habits. *Journal of Oral & Facial Pain and Headache, 31*(31), 30–36. https://doi.org/10.11607/ofph.1595

II Miettinen, O., Kämppi, A., Tanner, T., Anttonen, V., Patinen, P., Päkkilä, J., Tjäderhane, L., & Sipilä, K. (2021). Association of Temporomandibular Disorder Symptoms with Physical Fitness among Finnish Conscripts. *International Journal of Environmental Research and Public Health, 18*(6), 3032. https://doi.org/10.3390/ijerph18063032

III Miettinen, O., Lahti, S., & Sipilä, K. (2012). Psychosocial aspects of temporomandibular disorders and oral health-related quality-of-life. *Acta Odontologica Scandinavica, 70*(4), 331–336. https://doi.org/10.3109/00016357.2011.654241

Original publications are not included in the electronic version of the dissertation.