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Outi Huhtela

TEMPOROMANDIBULAR DISORDERS AND BRUXISM IN UNIVERSITY STUDENTS – PREVALENCE, ASSOCIATION WITH PSYCHOSOCIAL BACKGROUND FACTORS AND EFFECTIVENESS OF APPLIED RELAXATION

UNIVERSITY OF OULU GRADUATE SCHOOL;
UNIVERSITY OF OULU,
FACULTY OF MEDICINE;
MEDICAL RESEARCH CENTER OULU;
OULU UNIVERSITY HOSPITAL

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TEMPOROMANDIBULAR DISORDERS AND BRUXISM IN UNIVERSITY STUDENTS – PREVALENCE, ASSOCIATION WITH PSYCHOSOCIAL BACKGROUND FACTORS AND EFFECTIVENESS OF APPLIED RELAXATION

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Abstract

Temporomandibular disorders (TMD) comprise pain and disorders in the masticatory muscles, temporomandibular joints (TMJs), and adjacent tissues. The reported association varies between TMD and its background factors, such as psychological distress, other body pain, and recently much debated bruxism. Students comprise a special population at high risk for TMD with various individual stressors. Applied relaxation (AR) is a coping strategy developed to manage stressors; thus, it could also be applicable to TMD patients.

The aims of the study were to investigate the prevalence of TMD and bruxism, their mutual association, and their association with perceived risk factors in university students. The population sample in the Finnish Student Health Service (FSHS) survey in 2012 and 2016 consisted of a total of 7 646 students. The survey included questions on TMD symptoms, bruxism, distress (General Health Questionnaire-12), and other pains. Another aim was to investigate the effectiveness of the AR method in the treatment of TMD as compared to stabilization splint (SS). The sample in a randomized controlled trial consisted of 96 students, who were randomly assigned into two intervention groups: AR and SS group. Data on clinical examinations according to modified Axis I protocol of the Diagnostic Criteria for Temporomandibular Disorders, and on pain variables and psychosocial symptoms according to Axis II questionnaires of the Research Diagnostic Criteria for Temporomandibular Disorders with supplements were collected at baseline and at 3-, 6-, and 12-month follow-ups.

The prevalence of TMD pain, TMD pain on jaw movement, and TMJ locking was higher in 2016 as compared to 2012. Women reported TMD symptoms more than twice as much as men. Only minor differences in the prevalence of self-reported awake, sleep, and both awake and asleep bruxism were seen between 2012 and 2016. The mutual association between TMD and bruxism was significant, as were their associations with increased psychological distress and other musculoskeletal pains. As compared to SS, AR relieved TMD pain equally, but showed a more positive impact on non-specific physical symptoms and body pain.

In conclusion, self-reported TMD symptoms and bruxism are prevalent in students, sharing a common background. The AR method can be one option of treatment of TMD patients with psychosocial burden and other pains.

Keywords: applied relaxation, bruxism, psychological distress, student, temporomandibular disorders

Huhtela, Outi, Purentaelimistön toimintahäiriöt ja narskuttelu opiskelijoilla – esiintyvyys, yhteys psykososiaalisiin taustatekijöihin ja sovelletun rentoutuksen vaikuttavuus.
Oulun yliopiston tutkijakoulu; Oulun yliopisto, Lääketieteellinen tiedekunta; Medical Research Center Oulu; Oulun yliopistollinen sairaala
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Tiivistelmä

Purentaelimistön toimintahäiriöt (engl. temporomandibular disorders, TMD) koostuvat purema-lihasten, leukanivelten ja läheisten kudosten alueilla esiintyvistä kivuista ja toimintahäiriöistä. TMD:n ja sen taustatekijöiden, kuten psykologisen kuormittuneisuuden, muiden kipujen ja viime aikoina paljon keskustellun narskuttelun yhteys vaihtelee aiemmissa tutkimuksissa. Väestöryhmänä opiskelijat ovat alttiita TMD:lle omaleimaisten stressitekijöidensä vuoksi. Sovellettu rentoutus (AR) on stressitekijöiden käsittelyyn kehitetty elämänhallinta-menetelmä, joka voisi soveltua myös TMD-potilaille.

Tutkimuksen tavoitteena oli selvittää TMD:n ja narskuttelun esiintyvyyttä, keskinäistä yhteyttä ja yhteyttä koettuihin riskitekijöihin yliopisto- ja ammattikorkeakouluopiskelijoilla. Ylioppilaiden Terveydenhoitosäätiön organisoimaan väestötutkimukseen osallistui vuosina 2012 ja 2016 kaikkiaan 7 646 opiskelijaa. Väestötutkimuksessa kysyttiin TMD-oireista, narskuttelusta, psyykkisestä kuormittuneisuudesta (General Health Questionnaire-12) ja muista kehon kivuista. Lisäksi tavoitteena oli tutkia AR-menetelmän vaikuttavuutta TMD:n hoidossa verrattuna stabilisaatiokiskoon (SS). Satunnaistettuun kliiniseen tutkimukseen osallistui 96 opiskelijaa, jotka jaettiin AR-ryhmään ja SS-ryhmään. Tutkimuksessa käytettiin kansainvälisen diagnostisen kriteeristön (engl. Diagnostic Criteria for TMD) mukaista purentaelimistön tutkimusta (modifioitu Axis I) ja RDC/TMD-kyselykaavaketta (engl. Research Diagnostic Criteria for TMD, RDC/TMD) täydennyksineen.

TMD-kipuoireita levossa ja leuan liikkeessä sekä leukanivelen lukkiutuminen esiintyi enemmän vuonna 2016 kuin 2012. TMD-oireiden esiintyvyys oli naisilla yli kaksi kertaa yleisempää kuin miehillä. Narskuttelua valveilla, nukkuessa ja sekä valveilla että nukkuessa esiintyi vuosina 2012 ja 2016 lähes yhtä paljon. TMD:n ja narskuttelun keskinäinen yhteys oli tilastollisesti merkitsevä, samoin yhteys kohonneeseen psyykkiseen kuormittuneisuuteen ja muihin kipuihin. SS-hoitoon verrattuna AR lievitti samassa määrin TMD-kipua, mutta sillä oli myönteisempi vaikutus yleisiin fyysisiin oireisiin ja kehon kipuihin.

Johtopäätöksenä on, että koetut TMD-oireet ja narskuttelu ovat opiskelijoilla yleisiä ja niillä on yhteisiä taustatekijöitä. AR-menetelmää voidaan pitää yhtenä hoitovaihtoehtona TMD-potilaille, joilla on psyykkistä kuormittuneisuutta ja muita kipuja.

Asiasanat: narskuttelu, opiskelijat, purentaelimistön toimintahäiriöt, sovellettu rentoutus, stressi

Yesterday is but today's memory, and tomorrow is today's dream. ***(Khalil Gibran)***

To Ella, Lotta, Ville and Sanna

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September 26th, 2021 *Outi Huhtela*

Abbreviations

AB	awake bruxism
ACT	acceptance and commitment therapy
AR	applied relaxation
CBT	cognitive behavioral therapy
CI	confidence interval
DC/TMD	Diagnostic Criteria for Temporomandibular Disorders
FSHS	Finnish Student Health Service
GCPS	Graded Chronic Pain Scale
GHQ-12	General Health Questionnaire-12
i.e.	id est
IADR	International Association for Dental Research
IBS	irritable bowel syndrome
ICD	International Classification of Diseases
INfORM	International Network for Orofacial Pain and Related Disorders Methodology
n	population size
NSPS	nonspecific physical symptoms
OBC	Oral Behaviors Checklist
OPPERA	Orofacial Pain Prospective Evaluation and Risk Assessment
OR	odds ratio
p	probability value
RDC/TMD	Research Diagnostic Criteria for Temporomandibular Disorders
RCT	randomized controlled trial
SB	sleep bruxism
SD	standard deviation
SS	stabilization splint
TMD	temporomandibular disorders
TMJ	temporomandibular joint
UAS	university of applied sciences
Univ	academic university
VAS	visual analogue scale
χ^2	Chi-square

List of original publications

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

I 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

II Huhtela, O. S., Näpänkangas, R., Karppinen, J., Kunttu, K., & Sipilä, K. (2021). Association of psychological distress and widespread pain with symptoms of temporomandibular disorders and self-reported bruxism in students. *Clinical and Experimental Dental Research. 20 July.* https://doi.org/10.1002/cre2.472

III Huhtela, O. S., Koivisto, N., Hägg, V., & Sipilä, K. (2020). Effectiveness of applied relaxation method vs splint in treatment of temporomandibular disorders in Finnish students. *Journal of Oral Rehabilitation, 47*(2), 123–131. https://doi.org/10.1111/joor.12884

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1 Introduction

Temporomandibular disorders (TMDs) are an umbrella term for pain and disorders in the masticatory muscles, temporomandibular joints (TMJs) and associated structures (Okeson, 2020). TMDs comprise specific symptoms and signs in the masticatory muscles and TMJs, including muscle-related facial pain, restriction of movement of lower jaw, and TMJ noises, like clicking and crepitation, and pain symptoms in mastication-related tissues (Okeson, 2020). Non-specific symptoms are also common, such as headache, ache in the ear, tinnitus, hoarse voice, tired eyes, and pain in teeth or tongue (Ohrbach et al., 2016).

The etiology of TMD is multifactorial and includes biological and psychosocial factors. Psychosocial factors in the background of TMD are currently well taken into account in the diagnostics as they increase the risk of chronicity and impair the treatment outcome (Suvinen, Reade, Kemppainen, Könönen, & Dworkin, 2005); Huttunen, Qvintus, Suominen, & Sipilä, 2019; Maixner et al., 2011). The diagnosis of TMD is based on a comprehensive patient history and systematic clinical examination, complemented with radiological examination if needed. As TMD can be considered a musculoskeletal disorder it may also be associated with muscular pain in other areas of the body, as well as with widespread pain (Suvinen et al., 2005; Sipilä et al., 2011). Therefore, treatment of TMD patients may involve dental, medical and psychological aspects. A novel dual-axis biopsychosocial model with assessment of clinical somatic diagnoses (Axis I) and estimation of psychosocial burden and risk factors of pain chronification (Axis II) are included in both the Research Diagnostic Criteria of Temporomandibular Disorders (RDC/TMD) (Dworkin & Le Resche, 1992) and the recently developed Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) (Schiffman et al., 2014).

The prevalence of TMD symptoms is 25–50% in the general population (Köhler, Hugoson, & Magnusson, 2012). Women report and suffer from TMD pain at least twice as much as men (Kuttila, Niemi, Kuttila, Alanen, & Le Bell, 1998; Rutkiewicz, Könönen, Suominen-Taipale, Nordblad, & Alanen, 2006; Häggman-Henrikson, Liv et al., 2020). All age groups report TMD symptoms, but the symptoms seem to increase from young adulthood up to 50 years of age and decline slowly after that (Yekkalam & Wänman, 2014; Köhler et al., 2012; Lövgren et al., 2016; Qvintus, Sipilä, Le Bell, & Suominen, 2020; Banafa, Suominen, & Sipilä, 2020; Häggman-Henriksson et al., 2020a). In general population, the prevalence of TMD symptoms is highest in 35- to 50-year-olds (Kuttila et al., 1998; Lövgren et al., 2016; Köhler et al., 2012; Yekkalam & Wänman, 2014). Fluctuation is typical for TMD symptoms or facial pain in both long-term and short-term studies (Carlsson, 1999; Magnusson, Adiels, Nilsson, & Helkimo, 2004; Slade et al., 2014). Studies have shown that students, in most studies in the age-range between 18 and 35 years old, report more often TMD symptoms than the general population (Wieckiewicz et al., 2014; Lung, Bell, Heslop, Cuming, & Ariyawardana, 2018) (Table 1). Accordingly, due to their socioeconomic status linked with new social, educational, and economical stressors because of lower income (Stallman, 2010), students may be considered a special population group and may thus be at higher risk for TMD (Wieckiewicz et al., 2014; Sójka, Stelcer, Roy, Mojs, & Pryliński, 2019).

Bruxism refers to “both diurnal repetitive or sustained tooth contact by bracing or thrusting of the mandible; and nocturnal rhythmic or non-rhythmic masticatory muscle activities” (Lobbezoo et al., 2013, 2018); of these, sleep bruxism (SB) is currently considered to be regulated by the central nervous system (Lobbezoo & Naeije, 2001; Lavigne, Khoury, Abe, Yamaguchi, & Raphael, 2008) while awake bruxism (AB) is mainly related to psychosocial factors (Manfredini & Lobbezoo, 2010). The prevalence of bruxism varies in studies on general and student populations, with a higher prevalence seen in student populations (Wieckiewicz et al., 2014; Lung et al., 2018) (Table 1). Bruxism is considered one of the background factors for TMD as it may increase the load of the masticatory structures and thus provoke TMD pain (Baad-Hansen, Thymi, Lobbezoo, & Svensson, 2019; Jimenez-Silva et al., 2017; Manfredini & Lobbezoo, 2010). On the other hand, bruxism and TMD share some common background factors, such as psychosocial distress and widespread pain.

The most common treatments of both TMD and bruxism are self-care instructions, physiotherapeutic treatment, and occlusal splint therapy (Aggarwal, Fu, Main, & Wu, 2019; Shimada et al., 2019; Al-Moraissi et al., 2020; Türp, Komine, & Hugger, 2004; Wänman & Marklund, 2020). However, there are controversial studies on the effectiveness of occlusal splint therapy in reducing TMD-related pain (Qvintus et al., 2015; Klasser & Greene, 2009). As psychosocial factors play an important role in the background of TMD, treatments focusing on these might be sensible in a holistic approach to the treatment process. However, studies investigating the effectiveness of such treatments are scarce. Applied relaxation (AR), developed based on cognitive therapy methods, is one option for decreasing the stress response and thus alleviating pain.

The effectiveness of AR has been studied in patients with various pain conditions with promising long-term results (Türp et al., 2004). However, the effectiveness of AR has not been evaluated among TMD patients.

The present epidemiological cross-sectional survey was conducted to investigate the prevalence and the associated background factors of TMD and bruxism in university students based on the Finnish Student Health Surveys in 2012 and 2016. A randomized controlled trial (RCT) was conducted to evaluate the effectiveness of the AR method, as compared to stabilization splint, for treatment of TMD in university students in Northern Finland.

2 Review of literature

2.1 Temporomandibular disorders (TMD)

2.1.1 Definition

TMD is a collective term used for multifactorial facial pain and disorders in the masticatory muscles, the temporomandibular joint, and the adjacent tissues (Okeson, 2020). The origin of the pain or disorder can be muscle- or joint-related, or both. TMD is one of the most prevalent pain disorders and is considered the second most commonly occurring musculoskeletal pain condition after low back pain (NIDCR 2013; Schiffman et al., 2014). Musculoskeletal disorders are the greatest cause of disability in Europe (Cieza et al., 2021). More than one million Finns and every fourth adult in Europe have musculoskeletal pain conditions. In a review of ICD-11 work-in-progress classification, the International Association of the Study of Pain has suggested chronic TMD as a subclass of chronic secondary headache or orofacial pain disorders, with a definition of persistent or recurrent pain that lasts longer than three months (Treede et al., 2015; Benoliel et al., 2019).

From a neuroanatomical aspect, TMD pain is mostly musculoskeletal and transmitted through the second and third trigeminal nerve branches, occurring mainly under the orbitomeatal line, anterior to the pinnae and above the neck, in contrast to headache, which is located above the orbitomeatal line (Headache classification committee, 2018). However, in clinical practice headache and facial pain are often discussed together because of their symptomatic proximity.

2.1.2 Symptoms and signs

TMD comprise specific and non-specific symptoms in the masticatory muscles and TMJ. Specific symptoms include muscle- or TMD-related pain, restriction of the movement of the lower jaw, joint noises, such as clicking and crepitation, and pain symptoms in the masticatory structures (Okeson, 2020). The nonspecific symptoms of TMD can locate in the adjacent tissues and organs, such as teeth, tongue, eyes, ears, head, and throat. They are expressed as altered function or sensation like tinnitus, hoarse voice, tired eyes, and pain in teeth or tongue (Ohrbach et al., 2016). Other musculoskeletal conditions, like pain in the neck, limbs, or back, and widespread pain as defined pain in both limbs and spine, are also often adjoined with TMD symptoms in TMD patients (Velly et al., 2010; Sipilä et al., 2011; Ohrbach et al., 2011; Visscher et al., 2015; Maixner, Fillingim, Williams, Smith, & Slade, 2016).

Clinical signs of TMD include pain on palpation in the masticatory muscles and TMJs or surroundings of the TMJ, locking of the jaw, restricted jaw opening, or noises in the TMJ (Okeson, 2020). TMJ noises, such as clicking and crepitation caused by intra-articular derangement, for example, can be either painless or painful. However, TMJ intra-articular disorders, especially when painless, seem to have minimal impact on patients' reported pain, function, and disability (Chantaracherd, John, Hodges, & Schiffman, 2015).

2.1.3 Prevalence

The prevalence of subjective TMD symptoms varies in general population surveys from 25% to 50%, whereas that of clinical TMD signs varies from 40% to 90% (Carlsson, 1999; Jussila et al., 2017; Köhler et al., 2012). Discrepancies between the methods and populations in the studies cause variations in prevalence levels (Rutkiewicz et al., 2006; Qvintus et al., 2020; Häggman-Henrikson, Liv, et al., 2020). Among Finnish adults, the prevalence of at least one TMD sign was 38% in the Health 2000 Survey (Rutkiewicz et al., 2006; Qvintus et al., 2020), whereas the prevalence of TMD signs in the Northern Finland Birth Cohort (NFBC) 1966 was 34% at the age of 46 years (Jussila et al., 2017). According to recent studies, women report and suffer from TMD pain at least twice as much as men (Köhler et al., 2012; Gaue et al., 2016; Jordani et al., 2017; Sójka et al., 2018; Bueno et al., 2018; Häggman-Henrikson, Liv, et al., 2020). Genes (Visscher & Lobbezoo, 2015); hormonal and enzyme differences (Berger et al., 2015; Slade et al., 2015; Brancher et al., 2021) and behavioral aspects have been suggested to have a role in the gender differences (Vincent & Tracey, 2008; Sanders et al., 2013; Slade et al., 2015; Quinelato et al., 2018), but the discussion of the determinants of gender association continues.

All age groups suffer from TMD symptoms, but prevalence seems to increase from young adulthood up to 50 years of age, and decline slowly after that (Yekkalam & Wänman, 2014; Al-Jundi et al., 2008; Köhler et al., 2012; Lövgren et al., 2016; Qvintus et al., 2020; Banafa et al., 2020; Häggman-Henrikson, Liv, et al., 2020). A lower prevalence is observed in children and older adults, while the highest prevalence occurs between the ages of 35 and 50 years (Drangsholt & LeResche, 1999; Häggman-Henrikson, Liv, et al., 2020). Students (18- to 35-year-olds) report TMD symptoms more often than the general population (Wieckiewicz et al., 2014; Lung et al., 2018), and the prevalence of TMD pain symptoms has increased among Finnish students since 2000 (Oksanen, Laimi, Löyttyniemi, & Kunttu, 2014). The prevalence of perceived TMD symptoms in student populations varies between 8% and 77%. In a Polish study of 456 students, the prevalence of TMD symptoms was 18% in men and 36% in women (Wieckiewicz et al., 2014), whereas in an Australian study of 136 dental students 77% reported TMD pain and TMJ noises (Lung et al., 2018). Based on clinical examinations, TMJ clicking has been found to be the most common TMD sign. Of the diagnoses, student population has shown 8–28% prevalence of myalgia and 5–62% prevalence of joint-related TMD (Jivnani et al., 2019; Sójka et al., 2019; Fernandes, Duarte Moura, Da Silva, De Almeida, & Barbosa, 2017; Wieckiewicz et al., 2014; Lövgren, Österlund, Ilgunas, Lampa, & Hellström, 2018) (Table 1).

2.1.4 Background factors

According to the biopsychosocial model, the etiological factors of TMD may be divided into biological, psychological, and social factors (Suvinen et al., 2005; Fillingim et al., 2011).

A comprehensive project called Orofacial Pain: Prospective Evaluation and Risk Assessment (OPPERA) found that health status (general health, comorbid pain, sleep, headaches) variables contributed the most to TMD, followed by psychological (mood, anxiety, somatic symptom reporting, catastrophizing) and clinical (orofacial symptoms, parafunctions, palpation pain) orofacial domains (Ohrbach et al., 2011). The independent contribution to TMD incidence was much smaller in sociodemographic (age, race, marital status), pain sensitivity (thresholds of pressure, heat, and thermal pain), and autonomic function (heart rate and variability, blood pressure) domains (Bair et al., 2013; Slade et al., 2016). Typical risk factors include female gender, age group, comorbid pain, psychosocial factors, and parafunctions. A more profound association between higher incidence of TMD first onset and sex hormone exposure *in utero* favoring estrogen over testosterone was found in the OPPERA studies (Sanders et al., 2013). Occlusal factors as TMD risk factors have also been discussed; today, their role has often been excluded (Lobbezoo et al., 2010; Manfredini, Serra-Negra, Carboncini, & Lobbezoo, 2017), although opposite results have also been presented (Jussila et al., 2017).

Table 1. Studies on prevalence of temporomandibular disorders and bruxism in students.

Author / country	Year	Study population (n[1], gender, age)	Study methods[2]		Main outcomes
Niskanen / Finland	2021	dental students (n = 192) (36.5% men) (mean age 24.9, SD 4 years)	S	DC/TMD Symptom Questionnaire (SQ) and Patient Health Questionnaire-4 (PHQ-4)	TMD pain ever: 63% (56.5% of all men, 67.0% of all women), TMD pain during last 30 days 40.1% (women more than men), TMD pain during jaw movement 33.3%, TMD related temporal headache 40.5%, TMJ noises 51.1%, moderate/severe distress 9%. Association between distress and TMD pain/headache.
Patala / Finland	2021	dental students (n = 192) (36.5% men) (mean age 24.9, SD 4 years)	S	DC/TMD Axis II questionnaires: Oral Behavior Checklist (OBC), PHQ-4	SB 39.7% (30.9% men, 45.0% women), AB 19.9% (20.6% men, 19.5% women), clenching 48.4% (42.6% men, 51.8% women); distress 35.0% (27.9% men, 39.3% women)
Karabicak / Turkey	2020	healthcare students (n = 144) (100% female) (median age 20 years)	S	Fonseca's Anamnestic Index (FAI), OBC, Core Outcome Measure Index (COMI)	TMD 72.9%; TMD mild 48.6%, TMD moderate 18.1%, TMD severe 6.3% (FAI)OBC low 20.4%, high 80.6%; moderate or severe TMD: OBC high 68.1%. TMD severity is correlated with oral parafunctions and neck pain and function.
Karaman / Turkey	2020	dental students (n = 480) (40.2% men) (mean age 21.1 ± 1.8 years)	S	FAI, OBC, Oral Health Impact Profile-14 (OHIP-14)	TMD 53.3%; mild TMD 46.0%, moderate TMD 4.6%, severe TMD 2.7%; significant association between FAI and OHIP-14 and OBC, and OHIP-14 and OBC;
Medeiros / Brazil	2020	dental students (n = 113) (23% men) (mean age 21.5 ± 2.4 years)	S	OBC, DC/TMD SQ, Hospital Anxiety and Depression Scale (HADS-A and HADS-D); Social isolation total/partial/none	TMD 54.8% (27.4% painful, 27.4% non-painful) TMD symptoms; anxiety 49.6%, depression 44%, Positive correlation between oral behaviors and TMD, anxiety symptoms, and depression symptoms; Covid-19 isolation has impact on TMD symptoms, anxiety, and depression

Author / country	Year	Study population (n[1], gender, age)		Study methods[2]	Main outcomes
Nogueira Coutinho / Brazil	2020	science and technology students (n = 600) (37% men) (age range 18-45-year-olds)	S	RDC/TMD Axis II, FAI, bruxism	Bruxism 38.8 %, TMD 62.3% (52.5% men, 67.9% women), TMD and bruxism 82%, TMD without bruxism 49.9%; bruxism without TMD 18.0% significant association between TMD and age, and gender, and self-reported bruxism
Owczarec / Poland	2020	1st year dental (DS) and physiotherapy (PS) students (n = 105) (30.5% men) (mean age 20.1 ± 1.1)	C and S	TMD2Q + bruxism (SB), Perceived Stress Scale (PSS-10), HADS-A and HADS-D; clinical examination for parafunction signs, with EMG evaluation of m. masseter tone (MT left and right) in rest	TMJ pain 26%(PS) and 8% (DS), sleep bruxism 19%(PS) and 13%(DS); In both groups a tendency for simultaneous increase of stress, anxiety, depression and tone of masseter muscle
Phuong / Vietnam	2020	medical students (n = 568) (46.3% men) (mean age 22.2 ± 0.4 years)	C and S	self-reported bruxism (SB and AB). clinical DC/TMD Axis I examination and history; PSS-10, Educational Stress Scale for Adolescents (ESSA), OHIP-14	Bruxism 51.2% (49.4% in men, 52.8% in women), SB 38.2%, AB 23.4%, SB+AB 10.4%. stress, TMJ pain, TMD pain, attrition was associated with presence of bruxism. OHRQoL negatively related to bruxism
Jivnani/ India	2019	medical students (n = 200) (mean age 21.8 ± 2.0)	C and S	TMD Pain screener DC/TMD and HADS, Occlusion T-Scan	TMD diagnoses 17%, pain related TMD and headache 7.5%, intra-articular joint disorder 9.5% significant associations of TMD with psychological parameters and functional occlusal parameters
Sójka / Poland	2019	medical students (n = 271) (33.6% men) (mean age 21.3 years)	C and S	DC/TMD SQ, PHQ-4, 4Dimensional Symptom Questionnaire (4DSQ), Sense Of Coherence (SOC). DC/TMD Axis I clinical examination	TMD symptoms 33.2%, TMD diagnose myalgia 9.6%, disc displacement with reduction 4.8%. Bite parafunctions (AB or SB) men 27.5%, women 12.8%, Nonbite parafunctions men 45.1%, women 55%, stress men 81.2%, women 91.1%. Women showed higher level of somatization of stress, but higher capacity of coping than men did

Author / country	Year	Study population (n[1], gender, age)	Study methods[2]		Main outcomes
Xie / China	2019	students	C and S	systematic review and meta-analysis; prevalence and clinical signs	Overall TMDs 29.1% (27% in men, 30.6% in women), TMJ noises 17.4% (15.3% in men and 17.4% in women), muscle or joint related TMD pain 9.9% (9.1% in men and 11.5% in women).In 2011-2017: TMDs 35.1%, TMJ noises 26.5%, muscle or joint related TMD pain 12.3%; significant difference between genders; joint sounds 17.4%, abnormal jaw movement 12.3%, TMJ pain 9.9%. symptoms 29.1%
Lövgren / Sweden	2018	dental students (n = 54) (37% men) (median age 24 years)	C and S	DC/TMD Axis I examination, DC/TMD Axis II questionnaires: GCPS, JFLS-20, OBC; PHQ-15 (somatic)	any TMD DG 30%; myalgia 27.8%, arthralgia 14.8%, DDwR 5.6%, myofascial pain with referral 3.7%; local, regional, or widespread pain 65%. headache 15%; TMD patients scored higher pain intensity, higher jaw limitation, higher number of oral parafunctions;
Lung / Australia	2018	dental students (n = 136) (35.3% men) (mean age 22 years)	S	DC/TMD Axis I SQ	at least one TMD symptom: 77.2% (66.7% in men, 83% in women); TMD pain 48.5%, joint noises 48.5%, temporal headache 38.2%, jaw lock or catch 27.9%
Paulino/ Brazil	2018	high school students (n = 303) (31% men) (15–25 years, 15–19 years 93.1%)	S	FAI questionnaire (DMF index), clinical TMD examination, OHIP-14, HADS-A and HADS-D, emotional stress level on VAS	TMD symptoms (DMF index): female 65.3%, male 24.4%; parafunctional habits 87.5%, perceived stress 77.9%, anxiety 40.3%, depression 9.9%; TMD signs 12.2% in men, 43.6% in women; TMD signs and anxiety 26.4%; TMD symptoms and grinding teeth 12.2%, TMD symptoms and clenching teeth 24.8%
Karthik / India	2017	university students (n =4 02) (33.6% men) (age range 18–25 years)	S	FAI	muscle or joint related TMD pain mild 19.4%, moderate 2.7%, severe 0.5%; increased prevalence of symptoms in self-described tense people, significant association between trauma and TMD; prevalence of symptoms and signs women>men

Author / country	Year	Study population (n[1], gender, age)	Study methods[2]		Main outcomes
Loster / Poland	2017	age 18 general population/high school students (n = 260) (26.2% men) (mean age 17.9 years)	C and S	RDC/TMD Axis I clinical examination and Axis II questionnaires	muscle or joint related TMD pain diagnoses 26.5% (men 3.1%, women 23.5%), myofascial pain 20%, DDwR 9.2%, arthralgia 4.2%, osteoarthrosis 0.4%; one dg 20.1%, two dg 6.2%, three dg 0.4%; GCPS (pain) 8.5%
Rocha / Brazil	2017	dental students (n = 90) (mean age 19.9 ± 1.9 years)	S	FAI, General Health Questionnaire-60, World Health Organization Quality of Life-brief-24, State-Trait Anxiety Index	TMD symptoms 58.9%, women 32.2%; mild TMD 73.6%, moderate TMD 20.8%, severe TMD 5.7%. Psychologic domains, general health, psychosomatic disorders, anxiety, and quality of life influence the presence of TMD
Soares / Brazil	2017	university students (n = 253) (41.9% men) (mean age 21.5 ± 2.7 years)	C and S	questionnaire (stress, fatigue, anxiety), self-reported TMD symptoms, bruxism, clinical examination (dental wear)	Perceived bruxism (clench or grind) 31.7%; stress 76.3%, muscle pain (head, face, neck) 25.7%, TMJ pain 17.0%, TMJ noises 24.9%; muscle pain, TMJ pain, TMJ noise were significantly associated with bruxism
Yalçin Yeler / Turkey	2017	university students (n = 519) (43% men) (mean age M21.6 ± 2.3 years, F21.0 ± 2.0 years)	C and S	FAI, clinical examination; perceived sleep bruxism (PSB)	PSB 28.3%; TMD 96.6% of bruxers; PSB 42% of those having TMD; Frequency of TMD in bruxers: PSB 4% (nonTMD), PSB 52% (mild TMD), PSB 33% (moderate TMD), PSB 11% (severe TMD); 61.5% of those who had severe TMD had bruxism); PSB significantly associated with TMD, occlusal factors are not related to sleep bruxism
Cavallo / Italy	2016	science students (n = 278) (42% men) (mean age 23.7 years)	S	FAI (item 8; FAI8), PSS-10	FAI8: AB 37.9% (F40.8%, M34.2%); SB 31.8% (F33.3%, M29.1%); PSS-10 32.2 (SD 4.6, 95%CI 31.6-32.7) significant gender difference in stress score (men 31.2, women 32.9); A correlation between stress and awake bruxism exist only for male gender

Author / country	Year	Study population (n[1], gender, age)		Study methods[2]	Main outcomes
Emodi Perlman / Israel	2016	high school students (n = 1 000) (mean age 15.1 ± 1.5 years)	S	questionnaire (TMD2Q + neck pain + pain when waking up + sleep bruxing+ awake clenching or grinding + perceived stress)	SB 9.2% (boys 10.6%, girls 8.7%), AB 19.2% (boys = girls); orofacial pain 19.8%, neck pain 37.8%, TMJ noises 8.4, TMJ clicking 18.7%. Variables related to SB: TMJ sounds, feeling stressed; variables related to AB: TMJ sounds, orofacial pain, feeling stressed; a significant association between SB and AB; no gender relation; SB 9.2%, AB 19.2%; parafunction: chewing gum
Hongxing / China and Sweden	2016	high school students (n(Chi) = 5 524, n(Swe) = 17 015) (Chi 47.8% men, Swe 52.1% men) (mean age (Chi) 16.8 ± 0.9 years, mean age (Swe) 17.0 ± 1.5 years)	S	TMD2Q questionnaire	TMD pain 14.8% in Chinese population and 5.1% in the Swedish population; low paternal education level, poor general and oral health, living outside the home, rural school, poverty correlated with TMD in the Chinese population
Smiljic / Serbia	2016	medical and technical students (n = 319) (53.9% men) (mean age 20 ± 1 years)	S	Questionnaire orofacial pain (pain facial area/joints, muscles, function, temples, teeth)	Orofacial pain 32% (whereof 44% in men, 41% chronic pain); pain in temporal area 7%, TMJ pain 4%; pain when opening mouth wide 4%
Wieckiewicz / Poland	2014	medical, technical, and science students (n = 456) (42% men) (mean age 22.0 ± 2.1 years)	C and S	questionnaire + RDC/TMD Axis I clinical examination	TMD symptoms muscle tightness/fatigue 30%, headache 40%, otologic symptoms 19%, non-occlusal parafunctions 89%; women more than men; TMD signs 54%; disc displacement: women 29%, men 15%; muscle tightness (17+24%), occlusal parafunctions 64%; TMD diagnoses: muscle-related 18%, disc displacement 44%, other joint-related (arthralgia) 18%

Author / country	Year	Study population (n[1], gender, age)	Study methods[2]		Main outcomes
Akhter / Japan	2011	first year university students (n = 1 930) (50.8% men) (mean age 18.6 ± 2.1 years)	S	TMJ noises, TMJ pain, difficulty in mouth opening, aural symptoms, tinnitus, otalgia, vertigo, temple headache, depression, shoulder pain	TMD symptoms: one symptom (clicking/TMJ pain/difficulty in mouth opening) 18.5%, two symptoms 4.6% three symptoms 5.0%; at least one symptom 28.4%; Tinnitus, vertigo, and otalgia more frequently reported with TMD symptoms of TMD as compared to control
Vojdani / Iran	2012	dental and non-dental students (n = 200) (mean age 24.1 ± 2.9 years)	C and S	Helkimo´s clinical dysfunction Index (Di) and Anamnestic Index (Ai)	Ai: mild 30% (I), severe 2% (II); Di: mild 50% (I), moderate 13% (II), severe 8% (III); fatigue 14.5%, impaired range of movement 52%, impaired TMJ function 50%; TMJ noises 10.5%
Ryalat / Jordan	2009	students (n = 1 103) (25.0% men) (age range 18 to 25 years)	S	TMD symptoms: TMJ clicking, trismus, TMJ locking, pain on chewing or jawing, pain in or about the ears	at least one symptom 68.6%, whereof one 35.4%, two 24.3%, three 17.0%, four 14.4%, five 8.9%; otologic symptoms 45.6%; TMJ clicking 42.5%, pain on chewing 37.4%, trismus 22.9%, TMJ locking 14.2%; one
Nomura / Brazil	2007	dental students (n = 218) (44.0% men) (mean age 20 years)	S	FAI	TMD symptoms: 53.2% (mild 35.8%, moderate 11.9%, severe 5.5%) 40.6% of men, 63.1% of women
Oliveira / Brazil	2006	students (n = 2 396) (27% men) (mean age 22.1 ± 4.9 years)	S	FAI	TMD symptoms 68.6%: light 51.8%, moderate 13.9%, severe 4.3%; women 73.0%, men 56.3%

[1] number of participants, [2] C = clinical study, S = self-report study

Some evidence of heritability in the development of TMD pain has been shown in studies of familiar aggregation and genetic association (Visscher & Lobbezoo, 2015). Studies have found associations of genetic mapping with orofacial symptoms, pain sensitivity, and the effect of stress on pain (Smith et al., 2011; Smith et al., 2013; Slade et al., 2015; Sanders et al., 2017). TMD symptoms may also be linked with pain sensitivity which has a special genetic background (Slade, Smith, et al., 2013).

Biomechanical factors, such as parafunction and occlusal factors, can cause microtrauma (Jussila et al., 2018; Jimenez-Silva et al., 2017), which may predispose to TMD symptoms and signs. Macrotraumas may predispose to internal derangements of the TMJ or deformation of the TMJ (Gray & Al-Ani, 2010), effectuating a higher risk to develop TMD symptoms (Ryalat et al., 2009). For example, in whiplash trauma, strain may be concentrated in the cervical tissues of the ligaments of C1-C3, and hence symptoms and signs of TMD may develop years after the accident. A Swedish study showed an association between a history of whiplash trauma and TMD; however, the pathophysiology of whiplash seems to be different from TMD pain in the facial region (Häggman-Henriksson et al., 2013).

According to the general dictionary, parafunction as abnormal or disordered function comprises movements of the mandible that are outside normal function, for example nail biting or bruxism (The Free Dictionary). However, in dentistry, parafunctions and bruxism are considered as separate phenomena. Daytime oral parafunctions like chewing gum or objects, nail biting, non-functional or static tooth contact when awake, and sleep bruxism are associated with TMD symptoms (Berger et al., 2015; Blanco Aguilera et al., 2014; Jimenez-Silva et al., 2017; Funato et al., 2014) and signs (Paulino et al., 2018). Parafunctions increase the frequency of muscle contractions, elevation of electromyographic activity, and may lead to muscle hypertrophy. Experimental studies on blood oxygenation have concluded, for example, that individuals with high risk for developing TMD may have abnormalities in masseter and temporalis muscle deoxygenation (Shah, Melo, Reid, & Cioffi, 2019; Suzuki, Castrillon, Arima, Kitagawa, & Svensson, 2016).

The role of sleep bruxism as a parafunction or risk factor of TMD is under debate; here, it will be discussed in the chapter on bruxism (2.2).

Psychosocial factors

Psychological and social factors associated with TMD include distress (Ferrando et al., 2004; Tuuliainen, Sipilä, Mäki, Könönen, & Suominen, 2015; Niskanen, Hietaharju, Näpänkangas, Suvinen, & Sipilä, 2021), anxiety (Sójka et al., 2018), depression (Sipilä et al., 2001; Rantala et al., 2009), catastrophizing (Campbell et al., 2010; Häggman-Henrikson, Bechara, Pishdari, Visscher, & Ekberg, 2020, social relationships (Rocha et al., 2017; Marpaung et al., 2018), economy (Wetselaar, Vermaire, Lobbezoo, & Schuller, 2019), and work-related factors and non-specific physical symptoms (NSPS) (Suvinen et al., 2004; Suvinen et al., 2005; Manfredini, Piccotti, Ferronato, & Guarda-Nardini, 2010; Fillingim et al., 2011; Maixner et al., 2011). Distress is one of the important psychosocial factors and is defined as being subject to great strain or difficulties either physically or mentally (Merriam-Webster Dictionary) or as a feeling of great worry or unhappiness (Oxford Learner's Dictionaries). Distress as a concept is also defined by attributes such as inability to cope effectively, change in emotional status, harm, discomfort, and communication of discomfort (Ridner, 2004). These attributes also control the harmfulness of distress.

The relevance of psychological factors including somatic awareness in TMD has been ascertained by many studies in both general (Manfredini et al., 2010; Campbell et al., 2010; Fillingim et al., 2011, 2013; Sipilä et al., 2013) and student populations (Paulino et al., 2018; Slade et al., 2016), but it is still difficult to determine whether psychological symptoms predispose to TMD pain or vice versa (Wieckiewicz, Zietek, Smardz, Zenczak-Wieckiewicz, & Grychowska, 2017). The OPPERA study analyzed widely the association of psychological and somatic factors with the onset of TMD and found significant interaction between global psychological symptoms and TMD onset (Fillingim et al., 2013). Somatic awareness (Fillingim et al., 2011, 2013), health anxiety (Aggarwal, Tickle, Javidi, Peters, 2010), coping ability (Fillingim et al., 2011; Sójka et al., 2018), catastrophizing (Fillingim et al., 2011), and depression are factors playing a role in the long-term persistence of pain (Garofalo et al., 1998; Ohrbach & Dworkin, 1998).

Other pain conditions

Pain in other body areas (Sipilä et al., 2011; Slade et al., 2014), widespread pain, and fibromyalgia (Velly et al., 2010) are associated with TMD. The number of comorbidities is positively associated with the duration and intensity of TMD pain (Dahan, Shir, Velly, & Allison, 2015; Forssell, Kauko, Kotiranta, & Suvinen, 2017). Widespread pain, and bodily comorbid local pain complaints like headache, muscle soreness or pain, joint, back, chest, and menstrual pain often seem to precede TMD

(Lim et al., 2010; Nilsson List, & Drangsholt, 2013, Velly et al., 2010). Comorbid pains in TMD patients also frequently associate with fatigue and poor general health (Sanders et al., 2013; Jussila et al., 2018), such as painful and general health-decreasing irritable bowel syndrome (IBS) (Ohrbach et al., 2020).

The processes of pain are complex; similar pathways of separate nociceptive neurons, sensitization on different levels of the central nervous system and brain, and finally, referred pain sensation partly explain the different manifestations of TMD pain (Khalid & Tubbs, 2017; de Leeuw & Klasser, 2013).

Regional cervicogenic musculoskeletal pain with neck disability refers to the shoulders, arms, upper and lower back, and head. Separate regional musculoskeletal pains have common risk factors, and, on the other hand, the conditions may appear simultaneously. The increased pain load causes a change in the processing of impulses, and during chronification, larger areas of the brain cortex are involved, thus complicating treatment. In Finnish student population, co-occurrence of different pain symptoms and TMD symptoms was reported in 2000 and 2012; of those suffering from neck and shoulder pain, 9% also had TMD pain (Oksanen et al., 2014).

2.1.5 Diagnostics of TMD

The diagnosis of TMD is based on patient history, subjective symptoms, and clinical examination, supplemented with radiological imaging if needed. Questionnaires for assessing symptoms and background factors are included in the examination. A thorough clinical examination of a TMD patient includes registration of movements of the jaw and pain during movements, TMJ noises, and palpation of the masticatory muscles and TMJs. Registration of occlusion, pain on palpation in the neck and base of skull, mobility of TMJs, and pain on movements of the head are included in comprehensive examination of TMD patients.

Research Diagnostic Criteria for Temporomandibular Disorders

The internationally standardized protocol Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD), edited by Samuel Dworkin and Linda LeResche in 1992 (Dworkin & Le Resche, 1992), has since been revised and updated by the RDC/TMD Consortium, later called the International Network for Orofacial Pain and Related Disorders Methodology (INfORM). The reliability and validity of the RDC/TMD criteria have been tested (Dworkin et al., 2002; Truelove et al., 2010; Schiffman, 2010) and the protocol is widely used in high-quality studies. Clinical TMD diagnoses are set according to Axis I diagnostic algorithms, based on symptom questionnaire and clinical examination. The Axis II instruments, used for psychosocial assessment of the TMD patient, include a Graded Chronic Pain Scale 1.0 (GCPS 1.0) for assessment of pain intensity, pain-related disability, and chronic pain grade classification. Axis II also includes assessment of depression and non-specific physical symptoms (with or without pain items included), based on the Symptom Checklist 90-revised, SCL-90-R, during the preceding month (Von Korff, Ormel, Keefe, & Dworkin, 1992; Dworkin & LeResche, 1992; Derogatis, 1994). The depression scale assesses negative mood, and the NSPS include various complaints of cardiovascular, gastrointestinal, respiratory, and other autonomic systems, reflecting distress aroused by bodily perceptions (Dworkin & LeResche, 1992).

Currently, the RDC/TMD has been translated to Finnish and 20 other languages. All instruments for study assessment are available at the INfORM webpage www.iadr.org/INfORM/RDC-TMD in English, and in Finnish at https://ubwp.buffalo.edu/rdc-tmdinternational/wp-content/uploads/sites/58/2017/01/RDC-Finnish.pdf (Suvinen, Rantala, Ahlberg, & Könönen, 2010).

Diagnostic Criteria for Temporomandibular Disorders

The Diagnostic Criteria of Temporomandibular Disorders (DC/TMD) (Schiffman et al., 2014) was further developed from RDC/TMD for clinical and scientific settings. According to the DC/TMD, the dual-axis system reflects the biopsychosocial model with Axis I clinical diagnoses and Axis II assessment. Axis I includes TMD Pain Screener, DC/TMD Symptom Questionnaire and clinical examination protocol with mandatory commands which reveal pain-related (myalgia, myofascial pain, myofascial pain with referral, arthralgia, and headache attributed to TMD) and joint-related (intra/articular and degenerative joint disorders and subluxation) TMD sub-diagnoses. Diagnostic decision trees and diagnostic criteria have been drawn for diagnosis making. (Schiffman et al., 2014) Additionally, Axis II includes questionnaires on pain and pain-related disability, pain intensity, location of pain, NSPS, symptoms of depression and anxiety, parafunctional behaviors, and limitations in jaw function (Schiffman et al., 2014; Ohrbach & Dworkin, 2016), thus revealing individual risk factors and prognosis assessment which are prominent factors in treatment planning.

As RDC/TMD also DC/TMD has been translated to Finnish; the translation is available on the INfORM homepage https://ubwp.buffalo.edu/rdc-tmdinternational/tmd-assessmentdiagnosis/dc-tmd/ (Ohrbach, 2016).

Both RDC/TMD and DC/TMD have been applied to some student studies (Patala, Näpänkangas, Sipilä, 2021, Niskanen et al., 2021, Sójka et al., 2019, Lövgren et al., 2018, Loster, Osiewicz, Groch, Ryniewicz, & Wieczorek, 2017).

2.1.6 Treatment of TMD

TMD treatment need (7–9%) exceeds the demand (3–7%) in general population, where women are the majority (Kuttila et al., 1998; Carlsson, 1999; Magnusson, Egermark, & Carlsson, 2002). The treatment need is highest in the age range of 35 to 50 years (Kuttila et al., 1998; Köhler et al., 2012).

The aims of TMD treatment are to decrease pain and muscle tension, reduce discomfort and TMJ noises, and to improve limited jaw function. Conservative treatment, like counseling and patient education (Dworkin et al., 2002; Roldán-Barraza, Janko, Villanueva, Araya, & Lauer, 2014; Aggarwal et al., 2019), exercises (Storm Mienna et al., 2019; Armijo-Olivo et al., 2016), massage (Morell, 2016), manual therapy (Armijo-Olivo et al., 2016; Delgado de la Serna et al., 2020), and occlusal splint therapy (Roldán-Barraza et al., 2014), is recommended as first-line treatment (Wieckiewicz, Boening, Wiland, Shiau, & Paradowska-Stolarz, 2015). Good first-hand patient advice and education may have an impact on both TMD treatment need and demand. Additional treatments, like pharmacotherapy with pain medication, occlusal rehabilitation, psychological treatment, and surgical treatment are applied if needed (Häggman-Henrikson et al., 2017; Al-Moraissi et al., 2020; Nagori et al., 2018).

The current opinion agrees that tailored treatment based also on psychosocial assessment gives the most beneficial outcome (Dworkin et al., 2002; Kotiranta, Suvinen, & Forssell, 2014). Combining different treatment modalities gives the best results in most cases (Karibe et al., 2014).

Conservative treatment

Information and self-care

The first-choice elements of TMD symptoms management are to inform the patient of the etiology and risk factors of TMD, the generally good prognosis and treatment protocols at a dentist's practice, and to inform and educate the patient on self-care (Dworkin et al., 2002; Roldán-Barraza et al., 2014; Aggarwal et al., 2019; Storm Mienna et al., 2019; Armijo-Olivo et al., 2016). Self-care for TMD pain comprises warming or cooling aching muscles and joints, self-massage, motion and stretching exercises, relaxation, and pain medication if needed.

Treatment of TMD includes possible elimination of harmful behavior, masticatory muscle exercises, and targeted physical treatment, if needed. According to several studies, active exercise decreases TMD pain and affliction by increasing the mouth opening range, decreasing pain on moving jaw, and decreasing the need of pain medication (Armijo-Olivo et al., 2016). Patients with widespread pain often also benefit from active exercise (Storm Mienna et al., 2019), especially when exercises for surrounding tissues like the neck or upper back are included. These exercises include posture exercises and repeated tension and relaxation with minimal movement. Additionally, a recent study by Miettinen et al. (2021) on Finnish conscripts showed that good physical fitness in the neck-shoulder area may be a protective factor against TMD pain.

Florjanski et al. (2019) showed in their systematic review that different biofeedback methods (visual, audio, or electrical) can be useful in decreasing masticatory muscle activity, at least in the short term (Florjanski et al., 2019). Roy, de la Vega, Jensen and Miró (2020) studied the possibilities of neurofeedback on pain management and concluded that there may be potential for reducing pain and improving other related outcomes in individuals with chronic pain. However, all methods lack sufficient evidence for definitive conclusions on the effectiveness of biofeedback (Florjanski et al., 2019; Roy et al., 2020; Mishra, Gatchel, & Gardea, 2000; Raphael et al., 2013).

Physical therapy

Physical therapy strives to enhance and restore physical function of the masticatory muscles, joints, and related structures by utilizing non-invasive methods such as various manual therapies, mobilization and manipulation of TMJ and cervical neural tissue, massage, and soft low-level laser therapy. Physical therapy has primarily been suggested to be an effective treatment method (Wänman & Marklund, 2020; Wieckiewicz et al., 2015). Also, transcutaneous electrical nerve stimulation (TENS) (Zhang et al., 2020) and acupuncture have been used for immediate pain relief, for decreasing electromyographic activity, and for increasing the range of mandibular movement (Fernandes et al., 2017; Munguia et al., 2018).

Manual mobilization of TMJs and neural tissues and manual therapy of masticatory muscles, TMJs, and related structures such as cervical (C1-C3) joints and head, neck and upper back muscles decrease pain symptoms, perceived and palpation TMD pain, and increase the mobility of the jaw (von Piekartz & Hall, 2013; Armijo-Olivo et al., 2016; Paço, Peleteiro, Duarte, & Pinho, 2016; de Melo et al., 2020). Accordingly, as cervicogenic headache can be a contributing factor to TMD, targeting treatment at both the cervical and the orofacial area gives good results for both TMD symptoms and signs, and headache (von Piekartz & Hall, 2013).

The results from studies on manual therapy and therapeutic exercise are, however, controversial, partly due to the heterogeneity of the study protocols (Armijo-Olivo et al., 2019). Manual therapy alone or combined with relaxation methods has a better long-term impact than any of the above-mentioned alone in both myogenous and arthrogenous TMD (Calixtre, Moreira, Franchini, Alburquerque-Sendín, & Oliveira, 2015; Paço et al., 2016; van Grootel, Buchner, Wismeijer, & van der Glas, 2017). Promising results have also been achieved by combining physical therapy with occlusal splint treatment. In stepped care of myogenous TMD, physical therapy may be successful as primary therapy before occlusal splint (van Grootel et al., 2017).

Occlusal splint

An occlusal splint, made of processed acrylic resin, is a custom-made mouth guard attached to the teeth by friction for treatment of TMD. Stabilization splint (SS) is the most common type of splint used in TMD (Okeson, 2020). The benefit of use of SS is shown especially in most patients with joint-related TMD (Klasser & Greene 2009; Wänman, & Marklund, 2020). Temporary use of other common splints, reposition and relaxation splints, is recommended especially in painful TMD, but switching to stabilization splints after 2–3 weeks is recommended to avoid pathological changes in dentition (Tecco, Festa, Salini, Epifania, & D'Attilio, 2004).

In the literature, the results of the effects of SS are shown to be contradictory; some studies have shown that their pain-relieving effect is good or moderate (Wahlund, List, & Larsson, 2003; Magnusson et al., 2004; Zhang et al., 2020), whereas others have reported that splint use does not give any additional pain relief as compared to other treatments, such as counseling and masticatory muscle exercises (Truelove, Huggins, Mancl, & Dworkin, 2006; Qvintus et al., 2015). Qvintus et al (2015) found no significant difference between the groups in change of pain on visual analogue scale (VAS) before and after one-year follow-up. In fact, fewer patients (27.6%) in the splint group reported 'very good' treatment effects after the 1-year follow-up compared with the control group (37.5%). Al-Moraissi et al. (2020) conducted a network meta-analysis of the effect of hard SS compared to prefabricated or non-occluding splints, counseling therapy, and control. The evidence favoring any special SS treatment was low or very low. However, there was moderate evidence that counseling therapy is as effective as hard SS in TMDs of mixed origin. They also reported that anterior repositioning splints are favored over SS in mainly arthrogenous TMD.

The SS can, however, be considered a good non-invasive treatment approach, especially in TMD with restriction or pain on mandibular movement, even though the results on long-term effectiveness are contradictory (Zhang et al., 2020).

The controversial results of studies concerning conservative TMD treatment, such as the effect of splints, may derive from heterogenic study populations. For example, studies on the impact of the role of psychosocial factors on treatment outcome are scarce (Huttunen et al., 2019; Litt, Shafer, Ibanez, Kreutzer, & Tawfik-Yonkers, 2009). More studies evaluating the treatment response also using psychosocial instruments along with conventional outcome factors, like pain intensity, are needed.

Psychosocial interventions

Psychosocial intervention is an umbrella term; according to one definition, psychosocial interventions emphasize psychological or social factors rather than biological factors (Ganslev, Storebø, Callesen, Ruddy, & Søgaard, 2020). Psychosocial interventions comprise, for example mindfulness, cognitive behavior therapy, and different coping methods such as applied relaxation (AR).

Psychosocial interventions in TMD treatment are justified as psychosocial risk factors are relevant in the background of TMD (Suvinen et al., 2005). In general, psychosocial interventions in TMD pain have been successful for pain coping and acceptance, resulting in improvement of pain and disability compared with usual treatment. Improvements in mediators like pain catastrophizing and psychological inflexibility have been shown (Roldán-Barraza et al., 2014). Different psychosocial interventions can be performed in individual and group therapy and combined with other treatment methods (Kääpä, Frantsi, Sarna, & Malmivaara, 2006; Ehde, Dillworth & Turner, 2014).

Mindfulness

Mindfulness is a common individual and group therapeutic method for relieving psychological distress and musculoskeletal tension (Schumer, Lindsay, & Creswell, 2018). The goal of mindfulness-based interventions is to increase self-management rather than influence the experienced symptom, e.g. pain McCracken & Vowles, 2014). A meta-analysis of studies on mindfulness-based stress reduction concluded that mindfulness may contribute to better coping abilities in health issues (Grossman, Niemann, Schmidt, & Walach, 2004). Mindfulness-based treatment has been shown to reduce distress and stress especially in healthy people with psychological symptoms (Khoury, Sharma, Rush, & Fournier, 2015). Multiple studies show that mindfulness also reduces stress among cancer pain and chronic pain patients with significant decrease in distress and stress levels and increase of pain acceptance (Carlson, Bertrand, Ehrlich, Maxwell, & Burton, 2001; Plews-Ogan, Owens, Goodman, Wolfe, & Schorling, 2005). However, researchers are not unanimous, and a systematic review and meta-analysis was skeptic, and requested more high-quality studies with larger sample sizes, multidimensional scale measuring mindfulness, and choosing outcomes with value to patients (Bawa et al., 2015).

Cognitive behavior therapy

Cognitive behavior therapy (CBT) such as counseling, education, relaxation methods and acceptance and commitment therapy, aims to decrease the burden of pain.

Several studies have shown the utility of cognitive behavioral interventions in chronic pain (Williams, Fisher, Hearn, & Eccleston, 2020). In TMD treatment, also, CBT has shown to be effective (Aggarwal et al., 2010; Roldán-Barraza et al., 2014) as it focuses on changing the behavior that maintains or worsens distress, disability, catastrophic thinking, and pain (Williams et al., 2020). CBT has also shown to be cost-effective in treatment of TMD, especially at early stage (Stowell, Gatchel, & Wildenstein, 2007; Litt et al., 2009; Aggarwal et al., 2010). As a strategy developed within CBT, acceptance and commitment therapy (ACT) has been studied in pain subjects with good results (Wicksell, Olsson, & Hayes, 2010; Thompson et al., 2011). The treatment objective in ACT is to increase psychological flexibility also in the presence of interfering distress and pain. The treatment outcome of acceptance-oriented ACT has been compared with other CBT-based methods such as coping-oriented AR (Thorsell et al., 2011; Kemani et al., 2015; Kemani, Hesser, Olsson, Lekander, & Wicksell, 2016).

Litt et al. (2009) showed that pain and catastrophizing decreased significantly whereas active coping increased in interventions where CBT was combined with standard treatment in TMD patients (Litt et al., 2009). However, the decrease of pain level was not significantly higher with the combined intervention. They also showed that skills attained in CBT training add to the efficacy of other treatment modalities, especially in patients with low somatization or high self-efficacy (Litt et al., 2009).

Applied relaxation

Applied relaxation (AR) is a coping method developed from Jacobson's progressive relaxation by Professor Lars-Göran Öst in Sweden. Jacobson's progressive relaxation therapy (from the 1920s) is based on recognizing the difference between tight and relaxed muscle by tensing and relaxing specific muscle areas one at a time. Recognition of the difference also teaches awareness of one's body and physical sensations. Öst (1987) developed the method further, from awareness of physical sensations to controlling physiological events in the autonomic nervous system, which is the basis of AR (Öst, 1987).

The mechanism of the effect of AR is not clear, but several outcomes have been presented:

1. reduction of general tension in the body,
2. increased recognition and awareness of the problematic reaction,
3. increased self-esteem,
4. increased number of alternatives in a problematic situation, and
5. decrease of fatigue and feebleness (Öst, 1987).

In short, AR is a self-control method based on changing the autonomic response to psychological or physiological stimulus. Due to its active nature and easy usability, AR differs from other coping methods. The patient is taught to control the autonomic reactions, sensations, and mechanisms of his/her body through relaxation. The time needed for functioning relaxation to be achieved decreases gradually from 20 minutes to less than a minute and changes from conscious to subconscious activity through active training. (Öst, 1987)

The studies on AR assessment for psychological or psychiatric problems in the 1970's to 1990's showed beneficial results; personal CBT and AR have shown to relieve generalized anxiety disorder including worrying and stress (Öst & Breitholz, 2000; Hayes-Skelton, Roemer, & Orsillo, 2013). During the first decade of the 21st century, studies on behavioral medical treatment were carried out. Willumsen et al. (2001) showed good results in relieving dental fear with AR compared with nitrous oxide and cognitive therapy, with more regular dentist's check-ups and improved dental health as an additional outcome (Willumsen, Vassend, & Hoffart, 2001). Although positive results have been of short duration, AR and cognitive behavioral methods could be beneficial for persons with severe tinnitus (Andersson, 2002; Beukes, Manchaiah, Baguley, Allen, & Andersson, 2018), AR has also been more successfully used in treatment of headache (Ström, Pettersson, & Andersson, 2000) and back pain as compared to either usual rehabilitation therapy or no treatment in studies with a two- and twelve-month follow-up (Johansson, Dahl, Jannert, Melin, & Andersson, 1998; Marhold, Linton, & Melin, 2001).

The use of AR is based on the previous positive results of treatment of muscular or joint pain (Andersson, Johansson, Nordlander, & Asmundson, 2012; Kemani et al., 2015). Kemani et al. compared the impact of AR and ACT on pain and showed that the Pain Disability Index decreased more in ACT than in AR during active therapy. However, at three- and six-month follow-up both pain and disability remained lower or improved further in AR whereas they gradually deteriorated in ACT (Kemani et al., 2016), showing better longevity of AR. When comparing cost-effectiveness in the same study, ACT was more cost-effective than AR during therapy and at the 3-month follow-up, but no longer at 6-month follow-up (Kemani et al., 2015). Both AR and ACT have shown good results in coping and relieving pain although the mechanisms are different. (Hayes-Skelton et al., 2013).

To the best of our knowledge, the impact of AR on TMD has not been previously studied. However, as psychosocial factors and response to stress play a noteworthy role in TMD pain, methods like AR that increase coping ability may be beneficial especially for TMD patients with other pain symptoms or psychosocial loading. Also, as TMD is similar to other musculoskeletal pains, the impact of AR could be as successful as it has been shown to be in headache and back pain treatment.

2.2 Bruxism

Bruxism has traditionally been assumed to be an important background factor in TMD. A significant association between TMD and bruxism has been shown in both general and student population studies, based on self-report (Blanco Aguilera et al., 2014; Emodi Perlman et al., 2016; Jiménez-Silva, Peña-Durán, Tobar-Reyes, & Frugone-Zambra, 2017; Ekman et al., 2020; Nogueira Coutinho et al., 2020), as well on clinical studies (Magnusson et al., 2004; Manfredini & Lobbezoo, 2010; Paulino et al., 2018; Phuong et al., 2020; Soares et al., 2017; van Selms, Lobbezoo, Visscher, & Naeije, 2008; Yalçın Yeler, Yılmaz, Koraltan, & Aydın, 2017). However, the causality between bruxism and TMD is not known.

2.2.1 Definition

According to recent international consensus, the relevant indicator of bruxism is the masticatory muscle activity (Lobbezoo et al., 2018). Bruxism was earlier defined as oral parafunction with repetitive activity of the masticatory muscles characterized by teeth clenching, or grinding, and/or thrusting of the mandible. It included two distinct circadian manifestations during sleep, with excessive sleep arousal activity, or during wakefulness (Lobbezoo et al., 2013). Both states comprise elevated muscle tension and may cause stiffness and functional pain in masticatory muscles.

According to the current approach, a single definition for bruxism has been replaced by two separate definitions for sleep and awake bruxism (Lobbezoo et al., 2018). Sleep bruxism (SB) is a masticatory muscle activity during sleep that is characterized as rhythmic (phasic) or non-rhythmic (tonic). Awake bruxism (AB) is a masticatory muscle activity during wakefulness that is characterized by repetitive or sustained tooth contact and/or by bracing or thrusting of the mandible. Neither sleep nor awake bruxism is considered a movement disorder in otherwise healthy individuals; instead, it should be considered as a behavior that can be a risk factor for consequences like tooth wear, or TMD, but may also be a protective factor when associated with one or more positive health outcomes (Lobbezoo et al., 2018). Bruxism is also considered as one of many sleep disorders (International

Classification of Sleep Disorders) and is classified as a somatoform disorder in ICD-10.

2.2.2 Prevalence

Bruxism is most common in teenagers and young adults, its prevalence declining with age towards the late 60s (Lobbezoo, Ahlberg, Manfredini, & Winocur, 2012; Manfredini, Winocur, Guarda-Nardini, Paesani, & Lobbezoo, 2013) without significant gender differences in studies based on self-report (Ahlberg, Savolainen, Rantala, Lindholm, & Könönen, 2004; Manfredini et al., 2013).

The prevalence for awake bruxism is 19–29% (Lavigne et al., 2008; Carra et al., 2011) and for heavy sleep bruxism 10–16 % in the general population (Lavigne et al., 2008; Carra et al., 2011; Manfredini et al., 2013). The NFBC 1966 study reported that 38% of 46-year-olds reported sleep bruxism and 10% awake bruxism, women reporting more bruxism than men (Ekman et al., 2020). In a Brazilian study, 10% of the adults (n = 1 280) reported sleep bruxism based on interview (Pontes & Prietsch, 2019). They also reported that SB did not show any gender differences but did associate with higher education. In an Italian adult population study, the prevalence of bruxism in young adults, i.e. under 30 years of age, was 35% and declined with age (Ciancaglini, Gherlone, & Radaelli, 2001). A recent survey of young Dutch adults showed that of 17- and 23-year-olds, 4% reported awake bruxism and 8%–13% sleep bruxism (Wetselaar et al., 2019).

Bruxism is frequently reported in student populations (Soares et al., 2017; Yalçın Yeler et al., 2017; Nogueira Coutinho et al., 2020) (Table 1). Worldwide, the prevalence of parafunctions and bruxism in students varies between 17 and 89% (Jivnani et al., 2019; Lövgren et al., 2018; Lung et al., 2018; Paulino et al., 2018; Sójka et al., 2019; Vojdani, Bahrani, & Ghadiri, 2012; Wieckiewicz et al., 2014) (Table 1) The prevalence of awake bruxism among Israeli high school students (n = 2 347) was 19.2% and that of sleep bruxism 9.2% (Emodi-Perlman et al., 2016) while Nomura (2007) showed a bruxism prevalence of 72% in a study of 218 dental students (Table 1). Studies with students other than health care students are scarce. More studies with large populations of students from all study fields are needed to achieve results that are comparable with general population studies.

2.2.3 Background factors

Bruxism is a multifactorial, centrally inductive phenomenon. It has been suggested to be related to psychosocial factors, such as distress, depression, and anxiety (Lobbezoo & Naeije 2001; Lobbezoo et al., 2006; Ahlberg et al., 2013). The association of bruxism in the etiology of TMD has been widely discussed, whereas the association between psychological symptoms and bruxism is not clear (van Selms et al., 2017). Because of some common background factors, such as anxiety, distress, and elevated muscle contraction, the etiologies of both bruxism and TMD often are discussed side by side.

Besides psychosocial factors, several other risk factors for bruxism have also been presented, i.e. higher socioeconomic status (Wetselaar, Vermaire, Lobbezoo, & Schuller, 2021), personality, genetics (Lobbezoo, Visscher, Ahlberg, & Manfredini, 2014; Ahlberg et al., 2020), smoking and substance use (Ohayon et al., 2001; Rintakoski et al., 2010), medicines that influence serotonin and dopamine metabolism (Lavigne et al., 2001; Winocur, Gavish, Voikovitch, Emodi-Perlman, & Eli, 2003; de Baat et al., 2021), conditions like Parkinson's disease and Down syndrome (Ella, Ghorayeb, Burbaud, & Guehl, 2017; Verhoeff et al., 2021), and common mental disorders (Kinalski et al., 2019).

2.2.4 Diagnosis

Based on a consensus, the diagnosis of bruxism can be achieved on three different levels: possible, probable, and definite (Lobbezoo et al., 2013). Possible diagnosis is based on self-report, while probable diagnosis also requires a clinical examination with apparent oral manifestations, like buccal linea alba, impressions on the sides of the tongue, and tooth wear. Only tooth grinding sounds have strong evidence of association to bruxism (Lavigne, Rompré, & Montplaisir, 1996; Abe et al., 2009). Other clinical findings, such as tooth wear, muscle fatigue or pain, muscle hypertrophy, or temporal headache have several other background factors besides bruxism (Stuginski-Barbosa, Porporatti, Costa, Svensson, & Conti, 2017; Michelotti, Cioffi, Festa, Scala, & Farella, 2010). A definite diagnosis of sleep bruxism also requires polysomnographic or related recording. The fluctuating pattern of sleep bruxism complicates the use of one-night polysomnography to reveal random masticatory muscle events; home polysomnography with a self-applicable electrode set could thus provide a more definite diagnosis (Miettinen et al., 2018).

2.2.5 Treatment

Treatment of bruxism aims to alleviate pain and other symptoms as well as to protect teeth and surrounding structures from harmful forces. Lobbezoo and colleagues summarized the initial treatment modality of bruxism as triple-P: pep-talk, plates, and pills, referring to counseling, stabilization splints and short-term pharmacotherapy (Lobbezoo et al., 2008). Manfredini, Ahlberg, Winocur and Lobbezoo (2015) concluded that there is not enough evidence to define a standard of reference for the treatment of bruxism, except the manufacturing of oral splints, partly due to the low quality of studies (Manfredini et al., 2015). They also stated that there is a lack of evidence of the effects of various treatment modalities because of low-quality and scarce randomized trials. However, they recommended adding psychological and physical therapy to the triple-P treatment modality (Manfredini et al., 2017).

Occlusal splint

Stabilization splints are manufactured to protect the teeth and restorations from excessive wear and tear, thus not for treating bruxism but to prevent further damage and reduce the pain in teeth and masticatory structures. A summary of the effect of oral splint use on bruxism showed insufficient evidence of shortening bruxing time or decreasing bruxing episodes or reducing tooth wear compared with a control splint. However, more pain reduction was shown in bruxers with splints compared to no splint, minimal intervention, or placebo splints (Riley et al., 2020.)

Pharmacotherapy

Drug therapy with L-dopa inhibitors or antidepressants, for example (Macedo, Macedo, Torloni, Silva, & Prado, 2014) or injections like botulinum toxin have been used to treat bruxism in conditions with severely elevated muscle tonus (Häggman-Henrikson et al., 2017). High-quality RCTs are needed to evaluate the effect of botulinum toxin injections, although they may be effective as alternative therapy for reducing the symptoms of primary bruxism (Sendra, Montez, Vianna, & Barboza, 2020).

Psychological therapy

Psychological and physical therapy have been suggested to be included in the treatment of bruxism (Manfredini et al., 2015). For example, behavior modification (Glaros, Kim-Weroha, Lausten, & Franklin, 2007) and adapting muscle relaxation methods for stress reduction have been applied, especially for awake bruxism. Ommerborn et al. (2007) compared occlusal splint treatment with CBT among bruxers and found no significant difference between the two. The results in the CBT group were more positive in self-assessment of bruxism activity and in positive stress-coping strategies (Ommerborn et al., 2007). Valiente Lopez et al. (2015) compared combined improvement of sleep hygiene and progressive relaxation on sleep bruxism and sleep for a 4-week period using polysomnography, showing no significant difference in the outcome (Valiente López, van Selms, van der Zaag, Hamburger, & Lobbezoo, 2015).

Physical therapy

There is only weak evidence that physical therapy methods like electrotherapeutics, therapeutic and postural exercises or local therapy like acupuncture, muscle relaxation and massage would improve muscle pain and activity, health-related or psychological factors in persons with bruxism (Amorim, Espirito Santo, Sommer, & Marques, 2018). However, psychological as well as various physiotherapeutic treatments can be used auxiliary to occlusal splints in the treatment of bruxism (Manfredini et al., 2015).

Biofeedback

Biofeedback with or without mechanical applications is occasionally successful; some case studies on children or mentally challenged people applying repeatedly a tap on the cheek with a simultaneous command to open mouth have shown successful results (Armstrong, Knapp, & McAdam, 2014; Barnoy, Najdowski, Tarbox, Wilke, & Nollet, 2009). A significant correlation between reduced masticatory muscle activity and audio biofeedback, visual biofeedback training, or electrical stimulation intervention was shown in a systematic review (Florjanski et al., 2019). However, the evidence for the effect of biofeedback on bruxism is scarce as the quality of the studies included in the qualitative analysis was low or moderate.

As TMD and bruxism share common psychosocial background factors, AR as one modification of CBT could be effective for treatment of these conditions. Even though the studies on relaxation and biofeedback methods in the treatment of bruxism have not been able to show relevant effect, it may be speculated that treatment focused to a specific sample susceptible to psychosocial burden might be beneficial. This hypothesis is based on the positive effect of AR in treatment of musculoskeletal pain and psychological distress found in previous studies. Thus, as students have more distress than the general population and are at high-risk age regarding TMD and bruxism, they make an appropriate study population.

3 Aims of the study

The aims of the study were to evaluate the prevalence of TMD symptoms and self-reported bruxism, their mutual relationship and psychosocial background factors, and the applicability of the applied relaxation method in treatment of TMD among Finnish university students.

The specific research objects were to investigate the following among Finnish university students:

1. the prevalence of TMD symptoms and self-reported bruxism
2. the association between TMD symptoms and self-reported bruxism
3. the associations of psychological distress and widespread pain with TMD symptoms and self-reported bruxism
4. the effectiveness of applied relaxation method as compared to stabilization splint in treatment of TMD.

The working hypotheses were that TMD symptoms and bruxism are common among university students, they are mutually associated, and share distress and widespread pain as determinants.

Furthermore, we hypothesized that applied relaxation is an effective method as compared to occlusal splint in treatment of TMD.

4 Subjects and methods

4.1 Cross-sectional survey (Studies I, II)

The Finnish Student Health Service (FSHS) has implemented a comprehensive health survey every four years between the years 2000 and 2016 to undergraduate students in Finnish universities of applied sciences (UAS) and academic universities (Univ). In 2012 and 2016, the comprehensive data collection of students' physical, mental, and social health included questions on TMD symptoms and bruxism as one of the items of special interest.

4.1.1 Data collection

The survey questionnaire, available in both paper and in electronic format, included 168 (in 2012) and 126 (in 2016) questions on students' physical, mental, and social health, certain key-aspects of health-related behavior, the use of health services, and opinions concerning the quality of the services. In 2012, the following six questions on TMD and bruxism were included in the questionnaire:

1. TMD pain: Do you experience pain in the temples, temporomandibular joint, face or jaw once a week or more often? (with the following answer options: no/occasionally/all the time)
2. Some factors may provoke facial pain. Which factors provoke your facial pain? (I haven't noticed any provoking factors/cold/chewing/stress/something else, what?).
3. TMJ pain on jaw movement: Do you experience pain once a week or more often while opening your mouth wide or during chewing? (never or seldom/yes).
4. TMJ locking: Does your jaw lock once a week or more often? (no/yes),
5. Sleep bruxism/awake bruxism: Do your grind or clench your teeth tightly together? (no/only when sleeping/only awake/both asleep and awake).

Questions 1, 3, and 4 are validated for screening TMD in adult population (Lövgren et al., 2016). In 2016, the same questions (except 2) were used.

Table 2. Distribution of original sample by gender and respondents by gender, age and study level.

	2012 (n = 9 992)				2016 (n = 10 000)			
	men (n = 4 661)		women (n = 5 331)		men (n = 4 767)		women (n = 5 233)	
Group / Category	n	%	n	%	n	%	n	%
Sample								
UAS[1]	2 317	23.2	2 679	26.8	2 434	24.3	2 570	25.7
Univ[2]	2 344	23.5	2 652	26.5	2 333	23.3	2 663	26.6
Respondents								
UAS	711	16.2	1 267	28.8	400	13.0	833	27.0
Univ	917	20.8	1 508	34.2	664	21.5	1 185	38.5
Mean age (years)								
UAS	24.4		23.7		24.8		24.1	
Univ	25.2		24.7		24.6		24.3	
Age group/UAS								
< 25 years	421	25.9	882	31.8	184	18.1	465	24.8
25–29 years	222	13.6	284	10.2	134	13.2	208	11.1
30–34 years	68	4.2	101	3.6	52	5.1	95	5.1
Age group/ Univ								
< 25 years	430	26.4	834	30.1	296	29.2	548	29.3
25–29 years	354	21.7	493	17.8	275	27.1	433	23.1
30–34 years	133	8.2	181	6.5	73	7.2	123	6.6

[1] Universities of Applied Sciences, [2] Academic Universities

Psychological distress was assessed using the reliability-tested and validity-shown 12-item General Health Questionnaire (GHQ-12) (Goldberg et al., 1997; Oksanen et al., 2014; Hankins, 2008; Aalto, Elovainio, Kivimäki, Uutela, & Pirkola, 2012). The GHQ-12, used as a screening instrument to measure non-specific psychiatric morbidity with 12 items, includes questions regarding concentration, decision-making, coping with difficulties, feelings of usefulness, happiness, self-confidence, sleep disturbances, unworthiness, ability to enjoy, and ability to confront difficulties. Respondents were asked to rate the extent to which they had recently experienced any of the 12 symptoms using a 4-point Likert scale:

1 = not at all,
2 = same as usual,
3 = somewhat more than usual, and
4 = much more than usual.

The responses were combined into a sum score, the range being 12–48. A higher score indicated greater distress. Two out of the 12 questions could be missing and replaced by the mean value of the remaining GHQ-12 items of the individual. In the present study, GHQ-12 was used both as categorized and continuous. The score was further divided into quartiles (see 4.1.3. Statistical analysis), of which the two highest indicated elevated distress.

In 2012, the question for self-rated general health was: "How would you rate your own health?" (with the options good/quite good/average/quite poor/poor). For the analysis, the responses were classified into three subgroups: good (good/quite good), moderate (average), and poor (quite poor/poor).

In 2016, the format of the question was changed as follows: "How would you describe your current state of overall well-being?" (with the options very good/good/fairly good/poor/very poor). For the analysis, the responses were classified into three subgroups: good (very good/good), moderate (fairly good), and poor (poor/very poor).

Other pain items were inquired with the question "Have you had the following symptoms during the last month (30 days)?: Headache, neck or upper back pain, lower back pain, and pain in limbs" (with the options not at all/occasionally/weekly/daily or almost daily). The responses were dichotomized as 0 (not at all/occasionally) and 1 (weekly/daily or almost daily). Widespread pain was defined according to White, Speechley, Harth and Ostbye (1999), with some modifications; subjects who reported pain involving at least one extremity and either the neck or back were assessed to be suffering from widespread pain.

4.1.2 Design of the study

The FSHS research team prepared and sent a comprehensive questionnaire to students studying in Finnish academic and applied science universities. The sample sizes from each study level were equal (in 2012: 4 996 UAS and 4 996 Univ; in 2016: 5 004 UAS and 4 996 Univ). (Table 2) In 2012, 37% of the respondents were male and the total response rate was 44.3% (4 532 responses), while in 2016, 34.5% of the respondents were male, and the total response rate was 31% (3 114 responses). The age range was 18–35 years. The respondents represented well the target population for gender, age, study years, and disciplines (Kunttu & Pesonen, 2013; Kunttu, Pesonen, & Saari, 2017).

4.1.3 Statistical analysis

The prevalence of sleep and awake bruxism as well as TMD symptoms in Study I was described as numbers and percentages and stratified by gender, age was dichotomized into 25 years or less vs. 26 years or more. The answers to the questions on TMD pain were dichotomized as yes (occasionally/all the time) or no. Bivariate associations between TMD symptoms and bruxism (sleep bruxism, awake bruxism, and both sleep and awake bruxism) were evaluated using chi-square tests and Pearson's correlation coefficients, as described by odds ratio (OR) with 95% confidence interval (CI). The difference was considered statistically significant at $p < 0.05$. The associations between self-reported bruxism (dichotomized as yes or no) and TMD symptoms were evaluated using logistic regression model including age and gender.

For the analyses in Study II, age was dichotomized into 25 years or less vs. 26 years or more and the GHQ-12 score (range 12–48) was categorized to quartiles with cut-offs at ≤ 20, 21–23, 24–27, ≥ 28 of sum scores, respectively. Independent samples T-test was used to analyze differences in mean age and GHQ-12 scores between men and women. Chi-square tests were used to evaluate the associations of age group, GHQ-12 quartile, self-reported general health/wellbeing, other pain items, and widespread pain with gender and occurrence of TMD symptoms (TMD pain, pain in jaw movement, and locking) and bruxism (AB, SB, and having both AB and SB). Logistic regression models were used to evaluate the adjusted associations between distress (GHQ-12 score) and occurrence of bruxism (reporting both AB and SB), TMD pain and TMD pain on jaw movement. Associations were adjusted for age group, self-reported general health/wellbeing and presence of widespread pain. Separate models were run with GHQ-12 as continuous and categorized in quartiles. The mean of the GHQ-12 was calculated. The statistical analysis was performed by IBM SPSS Statistics 25 for Windows.

4.1.4 Ethical considerations

An ethical consent for the FSHS questionnaire study in 2012 was obtained from the Medical Ethics Committee of the Hospital District of Southwest Finland and in 2016 from the Ethics Committee of the University of Turku. Permission for the implementation of the study was given by the authorities of FSHS. The informed consent was obtained by voluntary response to the questionnaire. The answers could not be traced to individuals. (Kunttu & Pesonen, 2013; Kunttu et al., 2017).

4.2 Randomized controlled trial (Study III)

This randomized controlled trial was conducted between November 2011 and December 2014 at the FSHS Health Center in Oulu, Finland.

4.2.1 Design of the study and treatment procedures

The study population consisted of 96 TMD patients (students from the Universities of Oulu and Lapland) who had visited a doctor, nurse, dentist, dental hygienist, or physiotherapist due to symptoms related to TMD at the FSHS Health Center in Oulu. Power analysis was used to calculate the sample size. The age range was 19 to 34 years (mean 25.2 years, SD 3.7), 18% were men and 82% women. At the baseline appointment with the examining dentist the patients received information about the study protocol and a questionnaire to fill in at home. The patients signed the consent concurrently. After the baseline appointment the patients were assigned to two intervention groups: the AR group and the SS group, according to computerized randomization. (Fig. 1) The randomization was performed using IBM SPSS Statistics (version 18.0). The allocation was concealed to the examiner.

The AR treatment was administered by a trained physiotherapist according to the protocol by Öst (Öst, 1987) and modified by Thorsell (Thorsell et al., 2011) in six sessions with one-week intervals according to Fig. 1.

The splint treatment was conducted by a specialized dentist with dental laboratory manufactured heat-cured acrylic splints, with instructions to use them every night during the study; the centric relation for the splint was defined by using wax (Astynax®, Associated Dental Products Ltd). The fit, occlusal contacts in centric relation and wearing of the splint were checked approximately 2 weeks after the first fitting and re-checked when needed.

4.2.2 Data collection

The patients filled in a questionnaire on demographic data, general health, pain-related questions, and psychosocial assessment including the Finnish version of the RDC/TMD Axis II questionnaires on depressive symptoms and NSPS (Suvinen et al., 2010; Dworkin & LeResche, 1992) at baseline and at the 12-month follow-up. Intensity of facial pain was inquired using the following questions: "How would you rate your facial pain right now, on a scale from 0 to 10?” Body pain was inquired with the following question: “Have you had problems (pain, ache, discomfort) during the last year (12 months) in the following parts of the body: neck/occiput, shoulders, one or both hips, one or both knees, one or both ankles?" The answers were dichotomized as no/yes. A pain drawing of the body outline (back view) was used to identify the areas.

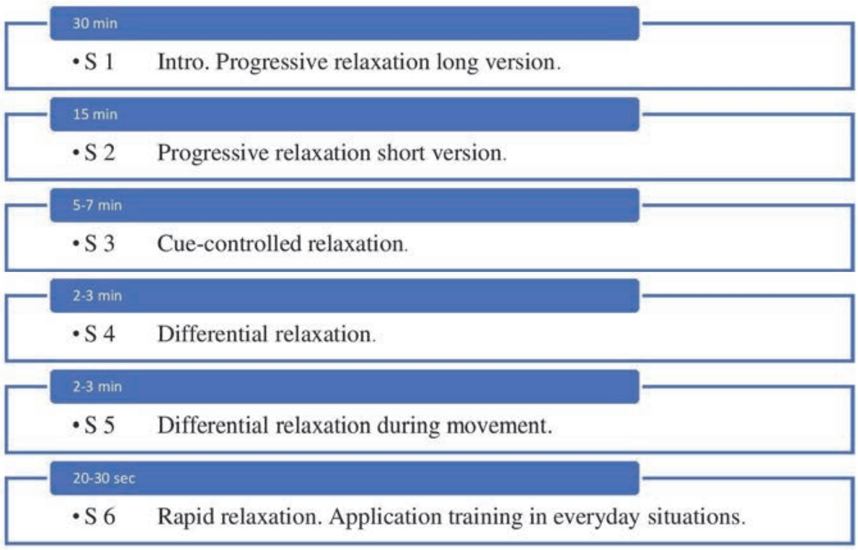

Fig. 1. Steps of AR intervention. Home exercise data was viewed and assessed during the sessions. S=sitting

Clinical examinations were performed according to the modified protocol of DC/TMD Axis I presented in a symposium at the International Association of Dental Research (IADR) conference in 2010 (Schiffman, 2010) at baseline, and at 3-, 6-, and 12-month follow-up for both groups (Fig. 2). The modified DC/TMD form included questions of TMD symptoms during the preceding 30 days. The clinical TMD examination form consisted of recording horizontal and vertical overjet, maximal mouth opening (without and with pain, limited if < 40 mm), familiar pain and TMJ noises (clicking and crepitus) during vertical and horizontal jaw movements, and a question on previous locking of the jaw. Familiar pain was recorded during palpation of temporal and masseter muscles, and around the lateral pole of the TMJ (1 kg) as well as on the TMJ (0.5 kg). However, due to the incomplete verification of the DC/TMD examination protocol pain referral and TMD-related headache were not recorded.

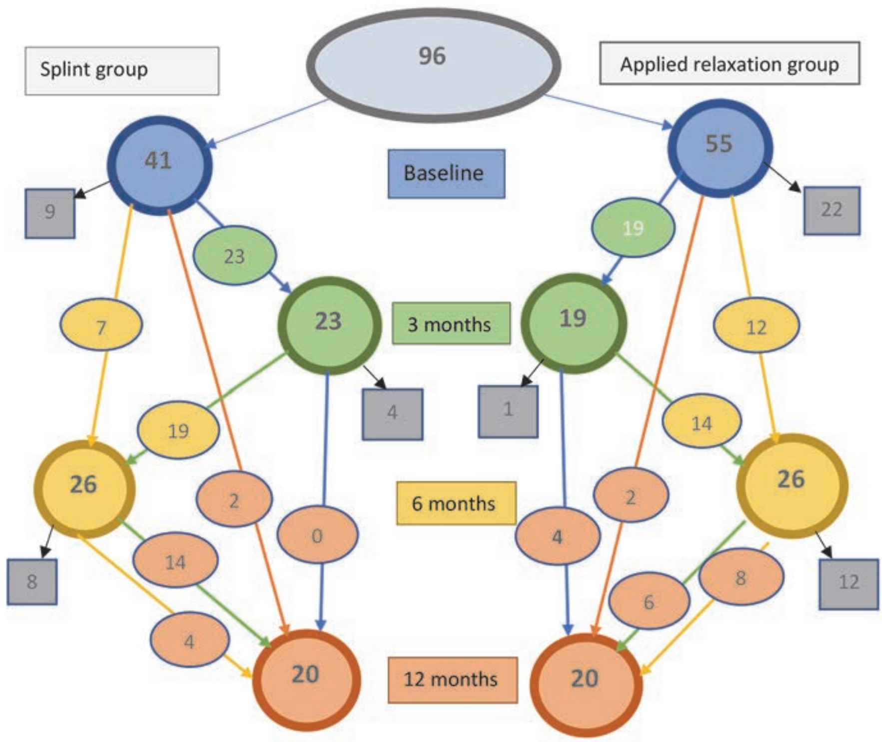

Fig. 2. Flow chart of the RCT study on TMD patients. Numbers inside bigger circles describe those patients who were included in the analysis. Grey boxes= drop-out.

The examining dentist (OH) was blinded to the applied treatment throughout the study period.

4.2.3 Statistical analysis

All data were analyzed by SPSS version 23 (IBM). The normality of the data was confirmed with Kolmogorov-Smirnov test using SPSS 25.0 and showed non-significance ($p = 0.65$). Drop-out analysis was used to evaluate variable differences between those who dropped out and those who stayed by using chi-square tests and Student's t-test for independent sample. The percentages of clinical TMD signs at baseline and every follow-up point were compared between the groups using chi-square tests. The outcome variables at baseline and follow-up were as follows: masticatory muscle palpation pain, restricted opening, TMJ noises, intensity of facial pain (VAS), depressive symptoms, NSPS with and without pain item (as evaluated in using RDC/TMD), and number of body pain sites.

The differences within groups in clinical signs were studied with ANOVA for repeated measures. The differences between groups in means of outcome variables at baseline and 12-month follow-up were analyzed with the independent samples *t*-test. Variable change was calculated by subtracting a variable at 12-month follow-up from the baseline variable. Significance was set as P-value 0.05.

4.2.4 Ethical considerations

Ethical consent for the clinical study was obtained from the Ethics Committee of the Northern Ostrobothnia Hospital District in 2011 (diary number 186/2011). The enrolled students gave their informed written consent at the first appointment with the examining dentist. The participants attended the study voluntarily and were permitted to interrupt their participation at any time without consequences. Each participant was given a study number to which the data was saved and analyzed. Anonymity was well protected. Single blinding was achieved as the examining dentist (OH) was not aware of which treatment had been assessed. The trial was retrospectively registered in the ISRCTN registry (study ID ISRCTN11790049).

5 Results

5.1 Prevalence of TMD symptoms and bruxism in Finnish students (I, II)

In 2012, TMD symptoms were reported by 41.1% of the study population. Women reported more than twice as many TMD symptoms than men (OR 2.70; 95% CI 2.27–3.22; $p < 0.001$). Continuous TMD pain (pain on temples, TMJs, face or jaw once a week or more often) was reported by 2.7%, frequent TMD pain by 20.5%, and occasional TMD pain by 17.8%. TMJ pain on jaw movement was reported by 7.6% and TMJ locking by 3.8% of the subjects. In 2016, frequent TMD pain was reported by 24.4% of the population, occasional TMD pain was reported by 20.4%, and continuous TMD pain by 3.0% of the subjects. Women reported more TMD pain than men. TMJ pain on jaw movement was reported by 7.9% in 2016, and TMJ locking once a week or more often was reported by 4.6% of the subjects (Table 3).

The prevalence of SB was 18.2% in 2012 and 15.6% in 2016 of the population, while the prevalence of AB was 2.3% in 2012 and 2.5% in 2016. The prevalence of self-reported bruxism was higher in women than in men in both 2012 and 2016, as 18.8% of men reported AB+SB in both 2012 and 2016 while 30.7% of women reported AB+SB in 2012 and 26.3% in 2016. (Table 3)

5.2 Association between TMD symptoms and bruxism in Finnish students (I, II)

SB was significantly associated with TMD pain symptoms in both genders in both 2012 and 2016 and with TMJ locking in both genders in 2012. AB was associated with TMD pain symptoms only in women in both 2012 and 2016. Bruxism (report of AB and/or SB) was associated with all TMD symptoms in both genders in both 2012 and 2016. The association between TMD pain symptoms and bruxism varied between OR 3.0 and 6.3, the greatest association being between bruxism and TMD pain in women in 2016 (Tables 4 and 5).

Table 3. Prevalence of self-reported temporomandibular disorder (TMD) symptoms and awake, sleep, and combined bruxism in Finnish students in 2012 and 2016. Associations with gender as described by odds ratio (OR) with 95% confidence interval (CI) and p-values.

Symptom	Prevalence (%)						OR (95%CI)		p-value	
	Men		Women		All					
	2012	2016	2012	2016	2012	2016	2012	2016	2012	2016
Frequent TMD pain	11.4	16.0	25.9	28.8	20.8	24.4	2.70 (2.27–3.22)	2.13 (1.7–2.57)	< 0.001	< 0.001
Continuous TMD pain	0.9	1.4	3.8	3.8	2.7	3.0	4.23 (2.45–7.29)	2.78 (1.59–4.86)	< 0.001	< 0.001
Occasional TMD pain	10.4	13.1	21.9	23.8	17.7	20.1	2.43 (2.02–2.91)	2.07 (1.69–2.54)	< 0.001	< 0.001
TMJ pain when moving jaw	4.2	4.8	9.6	9.6	7.6	7.9	2.40 (1.81–3.17)	2.10 (1.53–2.89)	< 0.001	< 0.001
TMJ locking	2.5	3.7	4.5	5.1	3.8	4.6	1.84 (1.28–2.64)	1.39 (0.95–2.03)	0.001	0.087
Sleep bruxism	12.5	12.3	21.0	17.4	17.0	15.6	1.86 (1.56–2.20)	1.51 (1.22–1.88)	< 0.001	< 0.001
Awake bruxism	2.8	3.1	2.0	2.1	2.3	2.5	0.71 (0.48–1.06)	0.68 (0.43–1.08)	0.093	0.102
Awake and sleep bruxism	3.2	3.4	7.2	6.6	5.7	5.5	2.35 (1.72–3.21)	2.04 (1.40–2.96)	< 0.001	< 0.001
Awake and/or sleep bruxism	18.8	18.8	30.7	26.3	26.3	23.7	1.91 (1.64–2.21)	1.54 (1.28–1.85)	< 0.001	< 0.001

Table 4. Association between self-reported bruxism, and symptoms of temporomandibular disorders in Finnish male university students, as described by odds ratios (OR) and 95% confidence intervals (CI).

Bruxism		TMD pain					TMJ pain on movement					TMJ locking				
		n	%	p	OR	(95% CI)	n	%	p	OR	(95% CI)	n	%	p	OR	(95% CI)
Sleep																
2012	yes	52	25.6	< 0.001	3.35	(2.33 4.82)	19	9.8	< 0.001	3.10	(1.78 5.42)	11	5.5	0.004	2.71	(1.33 5.22)
	no	129	9.3				46	3.4				29	2.1			
2016	yes	50	38.8	< 0.001	4.58	(3.06 6.88)	14	10.9	0.001	2.99	(1.57 5.72)	8	6.3	0.077	2.04	(0.91 4.56)
	no	112	12.1				36	3.9				29	3.2			
Awake																
2012	yes	5	11.1	0.949	0.97	(0.38 2.49)	0	0.0	0.165	0.97	(0.96 0.98)	1	2.2	0.894	0.87	(0.12 6.49)
	no	176	11.4				65	4.3				39	2.5			
2016	yes	8	24.2	0.190	1.71	(0.76 3.86)	2	6.1	0.734	1.29	(0.30 5.53)	1	3.0	0.834	0.81	(0.11 6.05)
	no	163	15.7				49	4.8				38	3.7			
Sleep and/or awake																
2012	yes	85	28.3	< 0.001	4.90	(3.54 6.79)	29	10.1	< 0.001	3.83	(2.31 6.36)	18	6.1	< 0.001	3.70	(1.96 6.99)
	no	96	7.5				36	2.8				22	1.7			
2016	yes	70	35.4	< 0.001	4.53	(3.15 6.51)	25	12.6	< 0.001	4.78	(2.68 8.52)	13	6.6	0.010	2.42	(1.21 4.85)
	no	92	10.8				25	2.9				24	2.8			

Table 5. Association between self-reported bruxism, and symptoms of temporomandibular disorders in Finnish female university students, as described by odds ratios (OR) and 95% confidence intervals (CI).

Bruxism		TMD pain					TMJ pain on moving jaw					TMJ locking				
		n	%	p	OR	(95% CI)	n	%	p	OR	(95% CI)	n	%	p	OR	(95% CI)
Sleep																
2012	yes	259	44.7	< 0.001	3.00	(2.47 3.64)	94	16.5	< 0.001	2.36	(1.80 3.11)	37	6.4	0.013	1.65	(1.11 2.45)
	no	454	21.2				162	7.7				85	4.0			
2016	yes	117	50.7	< 0.001	3.25	(2.56 4.13)	66	19.0	< 0.001	2.79	(2.02 3.86)	18	5.2	0.921	1.03	(0.61 1.73)
	no	397	24.0				127	7.7				83	5.1			
Awake																
2012	yes	25	46.3	0.001	2.48	(1.44 4.26)	11	20.0	0.008	2.42	(1.23 4.75)	4	7.3	0.317	1.69	(0.60 4.74)
	no	688	25.8				245	9.4				118	4.4			
2016	yes	24	55.8	< 0.001	3.21	(1.74 5.90)	8	19.0	0.036	2.27	(1.03 4.97)	5	11.6	0.048	2.53	(0.98 6.58)
	no	559	28.2				185	9.4				97	4.9			
Sleep and/or awake																
2012	yes	429	51.4	< 0.001	5.97	(4.96 7.19)	164	20.0	< 0.001	4.77	(3.64 6.25)	66	7.9	< 0.001	2.80	(2.81 7.57)
	no	284	15.1				92	5.0				56	3.0			
2016	yes	307	58.4	< 0.001	6.34	(5.10 7.88)	123	23.5	< 0.001	6.14	(4.49 8.41)	38	7.3	0.008	1.74	(1.15 2.64)
	no	267	18.1				70	4.8				63	4.3			

Logistic regression analyses showed significant associations between SB and TMD pain symptoms, and between AB+SB and all TMD symptoms in both genders at both time points. Additionally, SB was associated with TMJ locking in both genders in 2012, and AB was associated with TMD pain symptoms in women at both time points (Table 6).

Table 6. Significant associations between awake bruxism (AB), sleep bruxism (SB), both awake and sleep bruxism (AB+SB) and TMD symptoms according to the binary logistic regression analysis.

Symptom	TMD pain	TMD pain when moving jaw	TMJ locking
AB	b , d	b , d	
SB	a , b , c , d	a , b , c , d	a , b
AB+SB	a , b , c , d	a , b , c , d	a , b , c , d

a = men in 2012, b = women in 2012, c = men in 2016, and d = women in 2016

5.3 Association of psychosocial factors and widespread pain with TMD-related pain and bruxism in Finnish students (II, III)

Associations between self-reported TMD symptoms and age group, self-reported general health/wellbeing, psychological distress, and pain in other areas including widespread pain are presented in Tables 7 and 9. Associations of report of both AB and SB (AB+SB), SB, and AB with age group, self-reported general health/wellbeing, psychological distress, and pain in other areas including widespread pain are presented in Tables 8 and 10.

Poor self-rated general health was significantly associated with all TMD pain symptoms, and with AB+SB in women in 2012 and both genders in 2016.

In 2012, 22.6% of the population reported highest level of distress; of these, 75.3% were women. In 2016, 24.8% of the population reported highest level of distress; 70.2% of them were women. The presence of TMD symptoms increased with the level of distress in both genders and at both time points. Among women with the highest distress level, the prevalence of TMD symptoms (except for TMJ locking in 2016) was approximately two-fold as compared to those with the lowest level of distress, but the ratio decreased from 2012 to 2016. The same tendency was noted among men. The associations were significant in both genders at both time points, except for TMJ locking among women in 2016. Similar associations were found when using GHQ-12 as a continuous variable.

Table 7. Association of self-reported general health/wellbeing, and distress as General Health Questionnaire (GHQ-12) quartiles with symptoms of temporomandibular disorders (TMD).

Group	TMD pain (%)				TMD pain when moving of jaw (%)				TMJ locking (%)			
	Men		Women		Men		Women		Men		Women	
	2012	2016	2012	2016	2012	2016	2012	2016	2012	2016	2012	2016
	n=184	n=171	n=714	n=583	n=66	n=51	n=256	n=193	n=40	n=39	n=123	n=102
All [1]	11.4	16.0	25.9	28.8	4.2	4.8	9.6	9.6	2.5	3.7	4.5	5.1
Age group (y)												
18–25 (n = 2 965[3] / 1 818[4])	10.0	14.9	24.8	28.5	3.9	5.2	8.7	8.8	2.4	4.2	4.5	5.9
26–35 (n = 1 438[3] / 1 084[4])	14.0	18.8	28.5	34.8	4.7	5.0	11.4	12.2	2.8	3.6	4.6	4.6
p-value[1]	**0.015**	0.101	**0.039**	**0.005**	0.476	0.881	**0.028**	**0.020**	0.627	0.636	0.848	0.265
Self-reported general health / wellbeing												
poor (n = 127[3] / 134[4])	22.4	42.1	50.6	45.5	8.3	14.3	17.1	14.5	2.0	7.1	9.1	3.9
moderate (n = 578[3] / 685[4])	21.0	20.8	35.8	41.5	8.3	8.0	15.1	15.1	4.6	5.7	4.3	6.2
good (n = 3 671[3] / 2 262[4])	9.7	12.8	23.4	24.0	3.5	3.3	8.4	7.7	2.2	2.8	4.4	4.9
p-value[2]	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**0.003**	**< 0.001**	**< 0.001**	**< 0.001**	0.145	0.053	0.145	0.487
GHQ-12 quartiles												
Lowest (n = 1 259[3] / 862[4])	6.8	10.0	16.4	20.8	2.0	2.7	6.4	6.0	0.7	2.1	2.8	4.5
Medium low (n = 1 053[3] / 757[4])	10.5	15.4	22.1	24.7	4.2	4.2	8.1	9.2	3.9	1.8	4.0	4.5
Medium high (n = 990[3] / 626[4])	13.1	18.5	28.9	31.5	4.8	4.1	10.3	11.5	1.8	4.7	6.0	5.2
Highest (n = 963[3] / 743[4])	21.2	24.5	36.9	38.0	7.8	9.9	13.7	11.0	5.1	8.0	5.3	5.2
p-value[2]	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**0.003**	**0.001**	**< 0.001**	**0.014**	**< 0.001**	**0.001**	**0.028**	0.907

[1] Independent samples t-test, [2] Chi square, [3] 2012, [4] 2016, Bolded values $p < 0.05$

Table 8. Association of self-reported general health/wellbeing, and distress as General Health Questionnaire (GHQ-12) quartiles with bruxism (AB+SB), sleep bruxism (SB), and awake bruxism (AB).

Group	AB+SB (%)				SB (%)				AB (%)			
	Men		Women		Men		Women		Men		Women	
	2012	2016	2012	2016	2012	2016	2012	2016	2012	2016	2012	2016
	n=301	n=198	n=837	n=526	n=204	n=129	n=582	n=349	n=45	n=33	n=55	n=43
All [1]	18.8	18.8	30.7	26.3	12.8	12.3	21.3	17.4	2.8	3.1	2.0	2.1
Age group (y)												
18–25 (n = 2 965[3] / 1 818[4])	17.0	18.1	28.5	25.5	11.3	11.7	20.4	16.8	3.1	3.4	2.0	2.5
26–35 (n = 1 438[3] / 1 084[4])	22.0	22.0	35.7	33.6	15.3	14.7	23.5	22.5	2.2	3.1	1.9	1.7
p-value[1]	**0.015**	0.126	**< 0.001**	**< 0.001**	**0.023**	0.162	0.072	**0.003**	0.284	0.766	0.845	0.232
Self-reported general health / wellbeing												
poor (n = 127[3] / 134[4])	22.4	30.4	46.2	37.3	16.3	16.1	25.6	18.7	2.0	5.3	3.8	0
moderate (n = 578[3] / 685[4])	22.3	21.0	33.5	32.0	14.7	10.0	20.1	19.3	3.0	3.7	2.9	2.6
good (n = 3 671[3] / 2 262[4])	18.1	17.4	29.6	23.8	12.3	12.5	21.4	16.9	2.8	2.8	1.8	2.0
p-value[2]	0.289	**0.038**	**0.003**	**< 0.001**	0.469	0.407	0.549	0.497	0.926	0.506	0.155	0.301
GHQ-12 quartiles												
Lowest (n = 1 259[3] / 862[4])	13.5	16.7	27.5	20.4	10.3	11.6	22.0	14.5	1.8	2.7	1.0	2.5
Medium low (n = 1 053[3] / 757[4])	20.2	20.8	28.9	24.5	14.2	14.4	20.5	15.9	2.9	3.8	1.8	1.9
Medium high (n = 990[3] / 626[4])	19.8	17.8	31.5	28.6	11.6	10.5	21.5	20.2	3.8	4.1	1.8	2.1
Highest (n = 963[3] / 743[4])	28.0	19.8	35.4	31.7	17.8	10.8	22.1	19.4	4.2	2.3	3.5	2.3
p-value[2]	**< 0.001**	0.574	**0.008**	**< 0.001**	**0.022**	0.507	0.890	0.059	0.186	0.620	**0.009**	0.930

[1] Independent samples t-test, [2] Chi square, [3] 2012, [4] 2016, Bolded values $p < 0.05$

Table 9. Association of age group, other pain items, and widespread pain with symptoms of temporomandibular disorders (TMD).

Symptom	y/n	Count	TMD pain (%)				TMD pain when moving of jaw (%)				TMJ locking (%)			
			Men		Women		Men		Women		Men		Women	
			2012	2016	2012	2016	2012	2016	2012	2016	2012	2016	2012	2016
			n=184	n=171	n=714	n=583	n=66	n=51	n=256	n=193	n=40	n=39	n=123	n=102
All [1]			11.4	16.0	25.9	28.8	4.2	4.8	9.6	9.6	2.5	3.7	4.5	5.1
Other pain items														
headache	yes	(n = 788[3] / 2 039[4])	15.4	20.4	28.5	32.8	5.1	5.6	10.4	10.3	2.9	4.5	4.8	5.3
	no	(n = 3 574[3] / 867[4])	4.2	7.8	10.3	9.7	2.6	2.8	4.4	3.7	1.8	2.0	3.1	3.7
p-value[2]			**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**0.018**	**0.036**	**< 0.001**	**< 0.001**	0.186	**0.039**	0.137	0.168
upper back	yes	(n = 1 205[3] / 1 628[4])	17.6	20.7	30.3	30.4	6.1	5.1	16.1	10.0	3.0	6.2	5.1	5.6
/neck	no	(n = 3 132[3] / 1 042[4])	5.8	8.3	13.6	13.7	2.6	2.6	6.0	4.1	2.0	1.6	2.9	3.7
p-value[2]			**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**0.001**	**0.041**	**< 0.001**	**< 0.001**	0.199	**< 0.001**	**0.016**	0.090
lower back	yes	(n = 607[3] / 1 282[4])	16.6	22.2	32.1	37.5	8.9	6.8	11.3	13.6	3.4	5.3	5.1	6.4
	no	(n = 3 710[3] / 1 481[4])	7.8	11.0	19.6	20.7	3.8	3.1	4.5	5.5	1.9	2.8	4.0	4.4
p-value[2]			**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**0.001**	**0.007**	**< 0.001**	**< 0.001**	0.074	**0.044**	0.184	0.060
limbs	yes	(n = 374[3] / 903[4])	19.1	21.8	36.5	39.2	7.5	6.5	15.9	14.3	3.3	3.6	5.3	7.0
	no	(n = 3 933[3] / 1 820[4])	8.3	12.7	20.4	26.1	2.9	3.4	6.2	7.6	2.2	3.7	4.1	4.4
p-value[2]			**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**0.031**	**< 0.001**	**< 0.001**	0.226	0.954	0.172	0.022
Widespread pain														
	yes	(n = 260[3] / 597[4])	22.2	20.9	38.1	37.6	8.1	11.9	16.6	12.0	3.6	4.2	5.3	7.3
	no	(n = 4 015[3] / 1 727[4])	8.2	11.8	20.3	22.4	3.1	3.0	6.3	6.9	2.2	0.9	4.2	4.4
p-value[2]			**< 0.001**	**0.001**	**< 0.001**	**< 0.001**	**0.002**	0.235	**< 0.001**	**< 0.001**	0.149	0.630	0.183	**0.029**

[1] Independent samples t-test, [2] Chi square, [3] 2012, [4] 2016, $p < 0.05$

Table 10. Association of age group, other pain items, and widespread pain with bruxism (AB+SB), sleep bruxism (SB), and awake bruxism (AB).

Symptom	y/n	Count	AB+SB (%)				SB (%)				AB (%)			
			Men		Women		Men		Women		Men		Women	
			2012	2016	2012	2016	2012	2016	2012	2016	2012	2016	2012	2016
			n=301	n=198	n=837	n=526	n=204	n=129	n=582	n=349	n=45	n=33	n=55	n=43
All [1]			18.8	18.8	30.7	26.3	12.8	12.3	21.3	17.4	2.8	3.1	2.0	2.1
Other pain items														
headache	yes	(n = 788[3] / 2 039[4])	21.4	22.4	32.2	29.1	14.3	15.2	22.4	19.6	3.4	3.8	2.0	2.1
	no	(n = 3574[3] / 867[4])	14.0	13.7	21.8	15.2	9.9	8.7	14.9	10.2	1.8	2.3	2.0	2.4
p-value[2]			**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**0.011**	**0.002**	**0.001**	**< 0.001**	**0.070**	0.186	0.987	0.747
upper back or	yes	(n = 1 205[3] / 1 628[4])	23.6	23.7	32.4	28.0	15.6	16.1	22.0	19.1	3.4	3.1	2.2	2.1
neck	no	(n = 3 132[3] / 1 042[4])	14.5	13.7	25.9	17.0	10.2	8.9	19.5	12.2	2.3	2.9	1.4	1.9
p-value[2]			**< 0.001**	**< 0.001**	**0.001**	**< 0.001**	**0.001**	**0.001**	0.165	**0.001**	0.168	0.901	0.167	0.839
lower back	yes	(n = 607[3] / 1 282[4])	22.3	24.8	34.5	32.8	14.5	14.7	23.2	21.2	2.9	5.7	2.6	2.9
	no	(n = 3 710[3] / 1 481[4])	16.4	15.1	26.8	21.2	11.5	11.3	19.4	15.2	2.8	1.5	1.5	1.2
p-value[2]			**0.003**	**< 0.001**	**< 0.001**	**< 0.001**	0.081	0.122	**0.014**	**0.001**	0.862	**< 0.001**	0.405	**0.043**
limbs	yes	(n = 774[3] / 903[4])	25.3	23.6	35.3	32.3	17.3	16.0	23.4	20.7	3.9	3.9	2.5	3.1
	no	(n = 3 933[3] / 1 820[4])	16.2	17.8	28.2	26.1	10.9	11.6	20.2	18.0	2.4	3.1	1.8	1.7
p-value[2]			**< 0.001**	**0.042**	**< 0.001**	**0.006**	**0.001**	0.070	**0.047**	0.180	0.098	0.496	0.216	0.065
Widespread pain														
	yes	(n = 260[3] / 597[4])	27.3	24.5	36.2	31.3	18.0	16.0	23.7	21.0	4.4	4.7	2.7	3.2
	no	(n = 4015[3] / 1 727[4])	16.3	17.6	28.2	24.5	11.2	12.1	20.3	17.2	2.4	2.8	1.7	1.6
p-value[2]			**< 0.001**	**0.036**	**< 0.001**	**0.009**	**0.001**	0.160	**0.045**	0.095	**0.040**	0.196	0.354	0.078

[1] Independent samples t-test, [2] Chi square, [3] 2012, [4] 2016, $p < 0.05$

The presence of AB, SB, and AB+SB increased with increasing distress within GHQ-12 quartiles in women but varied in men. The association between distress and AB+SB was significant in both genders in 2012, and in women in 2016, whereas the association with SB was significant only in men in 2012. A tendency of stronger association between higher and lower distress and bruxism was noted but it was ascending only in women reporting AB+SB. When analyzing the associations with GHQ-12 as a continuous variable, the associations with AB+SB were significant, whereas the associations with SB and AB varied (Table 8).

In 2012, the provoking factors for TMD pain were reported as follows: stress (8.2%), chewing (5.8%), cold (1.5%), and other factors (3.0%). In 2012, 81.9% of those who reported stress as a provoking factor were women ($n^{women} = 295$, $n^{men} = 65$). Reporting stress as a perpetuating factor for facial pain increased the risk for SB report (OR 3.4, 95% CI 2.8–4.0) more than three-fold, that of AB (OR 1.7, 95% CI 1.1–2.6) almost two-fold, and that of both SB and AB (OR 4.4, 95% CI 3.3–6.0) more than four-fold.

All other studied pain items and widespread pain were significantly associated with all TMD pain symptoms both in 2012 and 2016, whereas TMJ locking was associated only with headache (in women in 2012, and in men in 2016) and upper back/neck pain (in women in 2012 and in men at both time points).

In the logistic regression analysis, higher distress was significantly associated with TMD pain symptoms and AB+SB in both genders in 2012, and in 2016, with TMD pain symptoms and AB+SB only in women (Tables 7 and 8). Widespread pain associated significantly with TMD pain symptoms at both time points, and with AB+SB in 2012 (Tables 9 and 10). Between the two time points a greater variability in these associations was seen in men than in women: in men, the association between widespread pain and bruxism was weaker and that between widespread pain and TMD pain symptoms stronger in 2016 as compared to 2012.

5.4 Effectiveness of applied relaxation method versus occlusal splint in treatment of TMD in Finnish students (III)

Of the studied population, temporomandibular myalgia was diagnosed in 100% and arthralgia in 41%. Of the subjects, 43.5% had only one diagnosis (myalgia), 46.7% had two diagnoses, and 9.8% had three or more diagnoses; both myalgia and arthralgia were present in 35%, while myalgia and/or arthralgia, and/or degenerative joint disease, and/or disc displacement with reduction was present in 29% of the subjects.

Almost all clinical findings decreased in the 12-month follow-up in both groups, with no significant difference between or within the groups. TMD signs fluctuated during the follow-ups. The percentage of masticatory muscle pain on palpation decreased during the 12-month follow-up in both groups. Masticatory muscle pain during jaw movement decreased in both groups, whereas TMJ pain in opening and/or closing jaw movement increased in the SS group and decreased in the AR group. Restriction in mouth opening increased slightly in both groups. There was some fluctuation in TMJ noises during the follow-up, and a slight decrease was noted in the SS group. (See original publication III, Fig. 2A-C)

At baseline, the differences between groups on all measured outcomes were non-significant. At baseline, the mean of VAS on pain intensity was 4.1 in the SS group and 3.7 in the AR group. At the 12-month follow-up, the corresponding values were 3.2 and 2.7. At baseline, the mean of the total score of depressive symptoms was 12.1 (SD 12.9) in the SS group and 12.5 (SD 11.4) in the AR group. At the 12-month follow-up, the corresponding values were 10.3 (SD 11.4) and 7.3 (SD 7.2). At baseline, the mean of the total score for NSPS with pain items was 12.8 (SD 7.7) in the SS group and 10.9 (SD 6.4) in the AR group, and the corresponding values for NSPS without pain items were 5.5 (SD 5.1) and 4.4 (SD 3.5). The mean of the total score for NSPS with and without pain items was significantly lower in the AR group than in the SS group at the 12-month follow-up ($p = 0.008$ and 0.016, respectively). At baseline, the mean number of body pain sites was at the same level in both groups, while it was significantly lower at 12-month follow-up in the AR group as compared to the SS group ($p = 0.004$).

6 Discussion

This thesis is based on two population-based surveys with comprehensive samples of university students in Finland and a smaller RCT to gather evidence of TMD-pain related factors and their treatment, comparing AR with SS in the treatment of TMD in students. The results showed that the prevalence of TMD symptoms and bruxism in students was high, as almost one fourth of the study population reported frequent TMD pain, and also about one fourth reported both awake and sleep bruxism. TMD symptoms and bruxism were mutually associated, and they were both associated with psychosocial factors. Prevalence of TMD pain also showed an increasing tendency from 2012 to 2016. An important finding was that the effect of AR was equal to SS in treatment of TMD pain, but it also showed more positive impact on non-specific physical symptoms and body pain as compared to SS treatment. These findings support the study hypotheses of high prevalence of TMD and bruxism, their mutual association, and sharing distress and widespread pain as background factors. AR treatment was comparable to SS in relieving local TMD pain, thus supporting the hypothesis, but had significantly more effect on psychosocial burden.

6.1 Prevalence of TMD symptoms and bruxism

In the present study, the prevalence of the most common self-reported TMD symptoms in Finnish university student population exceeded 20%, with a higher percentage in 2016 compared to 2012. The International Association for the Study of Pain reported in 2016 that TMD-related facial pain occurs in 9–13% of the general population, and, according to Köhler et al. (2012), the prevalence of at least one TMD-related symptom is 25–50%. Miettinen et al. (2017) reported that the occurrence of self-reported TMD symptoms in Finnish conscripts (n = 8 699, mean age 19.6 years) was between 6% and 28%, with the lowest prevalence in difficulty in jaw opening and the highest in TMJ clicking. Facial pain was reported by 15% of female and 14% of male conscripts. Compared to the conscript cohort, the present study showed that TMJ-related symptoms were less common in students. However, we studied the prevalence of jaw locking as once a week or more often (3.8% in 2012 and 4.6% in 2016), which is concordant with Miettinen's results on frequent or continuous jaw opening difficulties (2.7% in females and 0.3% in males).

The present study showed higher proportions for TMD pain (20–25%) as compared to two large Finnish population-based studies; the NFBC1966 study (Jussila et al., 2017) and the Health 2011 survey (Qvintus et al., 2020), both of which used the same validated questions on TMD. In the Health 2011 Survey on Finnish adults, the prevalence of TMD pain was 7% in the age group under 30 years, and in the NFBC1966, 18.5% among 46-year-olds. However, TMJ pain was approximately at the same level in all these studies. Furthermore, in a Swedish longitudinal population study (n = 180 308) by Nilsson, List and Drangsholt (2006), using the same questions on TMD pain, the prevalence in an almost equal age group was smaller as compared to the present study but showed similar increase from 2010 to 2017 (Häggman-Henrikson, Liv, et al., 2020). The increase in TMD symptoms in both the present and the Swedish study may relate to the multiplicity of factors, such as psychosocial distress and increasing awareness of pain, that may contribute to TMD incidence and persistence. They showed an incidence rate ratio of 2.37 (95% CI 2.25–2.50) with a higher risk for women as compared to men. They also found a twin peak pattern among women through the studied years; the first peak in 25-year-olds, and the second in 45-year-olds. They also showed that approximately 20% of individuals who develop TMD pain will develop a long-term pain condition (Häggman-Henrikson, Liv, et al., 2020).

It seems that students have more TMD pain than the general population, even in corresponding age groups. The prevalence of TMD pain (20–25% TMD pain and 8% TMJ pain) in the present study sample consisting of students from all study fields was comparable to other studies of student populations (Wieckiewicz et al., 2014; Lung et al., 2018; Akhter, Morita, Esaki, Nakamura, & Kanehira, 2011; Smiljic, Savic, Stevanovic, & Kostic, 2016; Soares et al., 2017). However, dental students have reported even higher prevalence; in a recent Finnish study (Niskanen et al., 2021) 40% of the dental students reported TMD pain (pain during the preceding 30 days, based on DC/TMD Symptoms Questionnaire). The higher prevalence of TMD symptoms in dental students has also been shown in other studies (Rocha et al., 2017; Smiljic et al., 2016; Lövgren et al., 2018; Medeiros et al., 2020; Niskanen et al., 2021) (Table 1). The higher prevalence's may be explained by dental students being likely to have more knowledge of TMD problems, which may influence their reporting. In the present study, TMD pain was more than twice as frequent in female students as compared to males, which is in accordance with other studies (Wieckiewicz et al., 2014; Paulino et al., 2018; Niskanen et al., 2021). Häggman-Henriksson (2020a) also argued that over time, the prevalence of TMD pain increases more in women than in men, creating an increasing gender difference, but this phenomenon could not be seen in the present study among students (Table 3).

According to the present study, bruxism is also a common phenomenon in the Finnish student population as about one fourth of the students reported awake and/or sleep bruxism. The prevalence of self-reported bruxism in studied student populations is around 30–40% (Soares et al., 2017; Yalçın Yeler et al., 2017; Nogueira Coutinho et al., 2020; Patala et al., 2021), which is in accordance with the present study. Corresponding prevalences have also been shown in general populations (Ekman et al., 2020; Blanco Aguilera et al., 2014; Manfredini et al., 2013). In the FinnTwin16 study consisting of five birth cohorts born in 1975–1979 (n = 3 124, mean age 24 years, range 23–27 years), bruxism was reported to occur weekly by 8.7% and rarely by 23.4% (Rintakoski et al., 2010). According to a systematic review, the prevalence of bruxism in adults ranged from 8% to 31%, of AB from 22% to 31%, and of SB from 1% to 15% (Manfredini et al., 2013). A decrease in SB prevalence with age has been shown (Manfredini et al., 2013).

In the present study, the prevalence of reporting SB only was 17%, report of AB only was low (2.4%), whereas report of AB+SB was higher (25%). The high prevalence of bruxism in young adults is also shown in other studies. In a recent survey study of Dutch 17- and 23-year-olds, 4% and 4% reported awake bruxism and 8% and 13% sleep bruxism, respectively, with higher prevalence in subjects with higher socioeconomic status (OR 3.0) in the 23-year-olds (Wetselaar et al., 2021). The outlines of the Dutch study are in concordance with the present study. In the NFBC1966 of 46-year-olds (Ekman et al., 2020), the prevalence of self-reported SB was 38%, and the prevalence of AB was 10%. However, the self-report of bruxism in NFBC1966 was based on alternatives no/yes, which includes relatively high possibility of bias as the frequency or longevity of either AB or SB cannot be estimated. A recent Finnish study on dental students (n = 192; mean age 24.9 years, SD 4.0 years) showed higher prevalence as compared to the present study in both self-reported sleep bruxism (40%) and awake grinding (20%) and clenching (48%) (Patala et al., 2021). They used the Finnish version of the Oral Behavior Checklist (OBC) included in the DC/TMD criteria (Schiffman et al., 2014). The difference may be explained by the high knowledge and awareness of bruxism behavior in dental students, and by the different time intervals used in the questions (the preceding 30 days vs. current behavior in the present study).

In the present study, the differences in SB and AB between the time points (2012 and 2016) were minor and non-significant. In the present study, SB showed higher prevalence in women than men, but not significantly in AB. This is in accordance with other studies of student populations (Paulino et al., 2018; Patala et al., 2021), with some exceptions (Lavigne et al., 2008; Carra et al., 2011; Cavallo, Carpinelli, & Savarese, 2016; Emodi Perlman et al., 2016), but also with general population (Ekman et al., 2020). Some studies have used more accurate methods for reporting bruxism. High specificity (0.83–1.00) and sensitivity (0.40–1.00) of portable devices for diagnosis of bruxism have been reported, whilst questionnaires and clinical examinations have shown similar specificity (0.63–0.99) but poorer sensitivity (0.13–0.94) (Casett et al., 2017). In the study on TMD patients (n = 293) by Muzalev, van Selms and Lobbezoo (2018) the frequency of bruxism was studied by using time items from 0 (not at all) to 4 (4–7 nights per week). The mean value for sleep bruxism was 2.53 (standard deviation (SD) 1.71) and for awake bruxism 1.45 (SD 0.89), the correlation between AB and SB being statistically significant. A new reliable tool for bruxism registration was introduced by Bracci et al. (2018) who assessed awake bruxism behaviors with a smartphone-based application and showed an average tooth contact (14.5%) and clenching (10.0%) frequency during awake time over a 7-day period (Bracci et al., 2018). Development of similar applications could be a relevant asset in population studies in the future.

6.2 Association between TMD symptoms and bruxism

In this study, the association between self-reported TMD symptoms and especially sleep bruxism was significant. This is in accordance with earlier studies in both general population (Paesani et al., 2013; Ekman et al., 2020; Muzalev et al., 2018; van Selms et al., 2017) and students (Emodi-Perlman et al., 2016; Soares et al., 2017; Yalçın Yeler et al., 2017; Nogueira Coutinho et al., 2020). The association between SB and TMD pain symptoms is also in accordance with the studies of Yalçın Yeler et al. (2017) and Nogueira Coutinho et al. (2020), showing that 97% and 82%, respectively, of the students with self-reported bruxism had TMD; more than a third of them had moderate or severe TMD when using the Fonseca's anamnestic index. However, polysomnographic studies have shown that the occurrence of TMD-related pain is not related to the intensity of SB (Smardz et al., 2019).

In the present study, a significant association between AB and TMD pain symptoms was shown only in women. Ekman et al. (2020) showed similar results, as the association was significant especially among women. The prevalence of AB in the present study was low, which may also impact the significance of associations. Interestingly, only few (5.8%) of the participants reported that chewing provokes their facial pain. This might be due to the fact that bruxism behavior and pain onset may occur with different timing, and due to lack of awareness of their connection.

The present study used questions on bruxism based on tooth clenching and/or grinding. There exist variations in the terminology concerning bruxism and parafunction. In earlier TMD studies bruxism has often been discussed as an oral parafunction (Michelotti et al., 2010), but in some studies bruxism has been separated from parafunctions (Emodi-Perlman, Eli, Friedman-Rubin, Goldsmith, Reiter, & Winocur, 2012). Oral parafunction is defined as abnormal or disordered function which in dentistry comprises movements of the mandible that are outside normal function, for example nail biting or bruxism. However, the definition of oral parafunctions has recently been extended to cover also biting of cheek, tongue, lip, and objects; resting chin on hand; and chewing or sucking objects, gum, ice, or lollipops (Winocur, Gavish, Finkelshtein, Halachmi, & Gazit, 2001; Paulino et al., 2018). Thus, the bruxism event has lately been considered as "elevated masticatory muscle activity which is either rhythmic (phasic) or non-rhythmic (tonic) during sleep (sleep bruxism) or thrusting or bracing the mandible with or without sustained or repetitive tooth contact when awake (awake bruxism)" (Lobbezoo et al., 2018). Both sleep and awake bruxism differ regarding the amount of force assessed or the time consumed from any of the parafunctions mentioned above and according to the multifactorial etiology of bruxism (Lobbezoo & Naeije 2001; Manfredini et al., 2010; Lavigne et al., 2008). On the other hand, awake and sleep bruxism undoubtedly share etiological factors such as stress and personality factors (van Selms, Lobbezoo, Wicks, Hamburger, & Naeije, 2004; Ohrbach, Gonzalez, Michelotti, & Schiffman, 2018; Wieckiewicz et al., 2014) and both are risk factors for TMD. Raphael and Lobbezoo have argued that bruxism is a behavior but may also be either a risk-factor or even a disorder in healthy people (Raphael, Santiago & Lobbezoo 2016). Parafunctions were not studied in the present study although it could be of some interest to compare the pathology behind parafunctions and bruxism.

6.3 Association of psychosocial distress with TMD-related pain and bruxism (II, III)

The present student population aged 26 to 35 years showed explicitly higher prevalence of highest distress in both men (15% in 2012, and 21% in 2016) and women (27% both in 2012 and 2016) as compared to Finnish general population.

In comparison, the Health 2000 study reported a 10% and 13% prevalence of distress in young Finnish men and women (age from 18 to 29 years), respectively (Koskinen, Kestilä, Martelin, & Aromaa, 2005), and 15% in men and 17% in women in 30- to 44-year-olds (Suvisaari et al., 2012). As in the present study, in the Health 2000 Survey GHQ-12 was used as an instrument for screening distress. Psychological symptoms have decreased between 2000 and 2011 in the general population (Suvisaari et al., 2012) while the prevalence of perceived psychological distress in students has increased between 2000 and 2012 (Oksanen, Laimi, Björklund, Löyttyniemi, & Kunttu, 2017), which was also noted in the present study. The contradictive results may be due to different stressors between populations; speculations of both personal pressure for better achievement and external pressure on economic and social status are prominent in students, while stress experiences in the general population traditionally arise from multifactorial work and quality of life issues (Testa & Simonson, 1996; Stallman, 2010).

The association between psychological burden and all studied TMD symptoms in the present study support earlier studies (Suvinen et al., 2004; Suvinen et al., 2005; Manfredini & Lobbezoo, 2010; Fillingim et al., 2011; Tuuliainen et al., 2015; Rocha et al., 2017; Sójka et al., 2019; Niskanen et al., 2021). Niskanen et al. (2021), using the Patient Health Questionnaire-4, showed that almost 50% of Finnish dental students (n = 192) had mild distress, while severe distress was present in 3% without significant gender or study level association. They also showed a significant association between distress and TMD symptoms, which is in accordance with the present study (Niskanen et al., 2021).

Although distress has strongly been associated especially with sleep bruxism in earlier studies (Saczuk, Lapinska, Wilmont, Pawlak, & Lukomska-Szymanska, 2019; Polmann et al., 2021), in the present study the association was significant only with combined (AB+SB) bruxism. This is in accordance with several other studies on students (Soares et al., 2017; Emodi-Perlman et al., 2016; Cavallo et al., 2016; Kinalski et al., 2019) and general population (Saczuk et al., 2019; Ahlberg et al., 2013). However, even though the results are not unanimous (Cavallo et al., 2016; van Selms et al., 2020), a recent systematic review and meta-analysis suggested, with some caution, a positive association between sleep bruxism and stress symptoms (Polmann et al., 2021). Recently, van Selms et al. (2020) reported an association between higher frequency of bruxism and elevated stress level in Finnish symphony orchestra musicians (mean age men: 47.7 years, mean age women: 43.4 years). An association was also shown between higher frequency of sleep bruxism and less than seven hours of sleep per night, which is common in student population. Female musicians and those with high-stress experience had more sleep bruxism (van Selms et al., 2020), which is supported by the present study.

Among 1 000 Israeli high-school students adolescents (age range 12 to 18 years) both SB and AB were associated with feeling stressed (Emodi Perlman et al., 2016), while in the present study a significant association between AB and distress was shown only in 2012. The association between AB and distress was significant only in women in 2012, while Cavallo et al. (2016) showed that AB correlated with stress only in men (Cavallo et al., 2016). However, the prevalence of self-reported AB was low, so no straightforward deductions of the association can be made based on the present study. The gender variation of bruxism and the association between distress and AB and SB between genders needs further studies. Studies on different positive and negative coping strategies in awake and sleep bruxers as well as between genders could give more information on the variation of the association between distress and AB and SB (Schneider et al., 2007; Reissman et al., 2012; Soto-Goñi et al., 2020).

It also seems relevant to study the association between distress and TMD symptoms as well as distress and bruxism in relation to time. Recent studies in Italy, Poland, and Israel on general population during the Covid-19 pandemic show a clear increase in both distress and TMD symptoms (Saccomanno et al., 2020; Emodi-Perlman et al., 2020). In Emodi-Perlman's study, 34% of the Polish and 15% of the Israeli responders reported aggravation of TMD symptoms since the lockdown. They showed an aggravation of 34% of AB and 28 % of SB by the Polish and 16% and 13% by the Israeli responders, respectively. One of the main elevated stressors was the economic situation, which along with living away from home and an uncertain future is also common in the Finnish student population. The period of social distancing and compromised economic situation will probably leave traces visible as psychosocial and somatic symptoms for years to come, as shown after earlier periods of economic depression (Stuckler, Basu, Suhrcke, Coutts, & McKee, 2009); Toffolutti & Suhrcke, 2014).

The increase in TMD symptoms between 2012 and 2016 may be coincidental but may, on the other hand, show unfavorable development of individual health, poor sleep quality and ergonomics, increased psychological distress, screen time (statista.com, Huotari, Aunio, Paavola, & Kallio, 2019; Odgers, & Jensen, 2020). In addition, the general information and acknowledgement of pain symptoms in masticatory muscles has probably increased. The relationship between distress and pain may be bidirectional; distress may provoke pain, and on the other hand, pain conditions can lead to distress.

6.4 Association of widespread pain with TMD related pain and bruxism

The associations between all TMD symptoms and other pain items in the present study were significant. The high prevalence of other pains, especially in 2016, such as pain in the neck or upper back (52%), lower back (41%) and stomach (43%), was surprising, although musculoskeletal conditions and first diagnosis of different enterodynias, such as IBS and Crohn's syndrome, is often made before the age of thirty (Ohrbach et al., 2020; Kalla, Ventham, Satsangi, & Arnott, 2014). According to Oksanen et al. (2014) the prevalence of musculoskeletal syndromes and pain is increasing in Finnish students. An association has been shown to exist between neck disability and TMD (Olivo et al., 2010). This is in accordance with the present study as in 2012, 28.3% of men and 41.2% of women, and in 2016, 37.6% of men and 46.2% of women with TMD pain reported neck and upper back pain. The association between neck disability and TMD has been shown to exist (Olivo et al., 2010), thus supporting the present results. On the other hand, good physical fitness and physical activity might be protective factors against TMD (Miettinen et al., 2021) as well as neck and shoulder pain (Kaartinen et al., 2019), which is closely related to TMD.

The present study results are supported by previous longitudinal and cross-sectional studies. Pre-existing psychosocial factors like poor general health (Rantala et al., 2003; Sanders et al., 2013; Yekkalam & Wänman; 2014), regional musculoskeletal pain (Nahit, Pritchard, Cherry, Silman, & Macfarlane, 2001), chronic widespread pain (MacBeth J et al., 2001), and low back pain (Nahit et al., 2001) may predict the onset of TMD pain. Subjects with TMD have reported more comorbid disorders (Visscher et al., 2015; Plesh, Adams, & Gansky, 2011) and widespread pain than controls (Velly et al., 2010; Sipilä et al., 2013). According to a comprehensive population survey (the 2000–2005 US National Health Interview Survey), only 0.77% of those reporting myogenous TMD pain did not report any comorbid pain, whereas 59% reported two or more comorbid pains (Plesh et al., 2011). In addition, those with arthrogenous TMD reported severe headache (53%), neck pain (54%), low back pain (64%), and joint pain (62%). Vissher et al. have shown similar results in the Dutch population (Vissher et al., 2015). Also, according to a clinical North American study, the presence of some conditions, such as migraine and chronic fatigue syndrome, was associated with an increase in TMD intensity and duration (Dahan et al., 2015).

The statistics show an increase in illnesses and musculoskeletal conditions, and the need for rehabilitation in different musculoskeletal disorders is increasing worldwide (Cieza et al., 2021). Thus, general practitioners face challenges in management of cases with widespread pain and less understood disorders like TMD (Gil-Martínez, Paris-Alemany, López-de-Uralde-Villanueva, & La Touche, 2018).

The association between bruxism and widespread pain varied in AB+SB, and was nonsignificant in AB and SB. However, the association between bruxism and musculoskeletal upper back or neck pain and headache was significant. This is in accordance with other studies (Baad-Hansen et al., 2019). Elevated muscle tonus and prolonged tension during grinding teeth or thrusting the mandible forward causes tension also in the neck and the cervical area, which makes cervicogenic headache common in bruxers and TMD patients (von Piekartz & Hall, 2013).

6.5 Effectiveness of applied relaxation

As psychosocial risk factors are important in the background of TMD, the use of psychosocial interventions like relaxation or self-regulation in TMD treatment is also justified. Self-reported local pain is the most common outcome variable in clinical TMD studies. However, besides local TMD pain, psychosocial factors were also included as outcome variables in the present study due to the high prevalence of other pain items and NSPS in TMD patients as compared to general population (Reissmann, John, Schierz, Seedorf, & Doering, 2012). In the present study, NSPS at baseline and 12-month follow-up decreased significantly more in the AR group as compared to the SS group (4.8 vs 1.8 respectively) showing clinically significant decrease in the AR group. The difference between the groups was significant also considering body pain sites and masticatory muscle and TMJ pain on palpation. A clinically significant decrease of depressive symptoms was shown in the AR group.

The AR method is closely related to physical self-regulation (PSR) studied by C.R. Carlson (2001). In both methods, the aim is to decrease the high muscle activity by relaxation, with promising results in pain relief as shown in studies (Carlson et al., 2001; Thorsell et al., 2011). The relaxation in both methods is achieved by regulation of the autonomic nervous system and altering the parasympathetic response to stressors. TMD patients may have a dysregulation of the autonomic system (Monaco, Cattaneo, Marci, Pietropaoli, & Ortu, 2017), which may be altered in AR by repeatedly implemented tension-relaxation, and later short relaxation exercises. According to Buchholz, Kelly, Bernatene, Méndez Diodati and Gelpi (2017), the relaxation of n. trigeminus innervated m. masseter may enable activation of the trigeminocardiac reflex which affects the autonomic nerve function (Buchholz et al., 2017).

The AR method is also a positive coping strategy, which became apparent in discussions with the participants in the present study; many of them reported a reduction of negative stress in public study-related presentations. TMD patients tend to show negative coping strategies, such as behavioral disengagement like self-pity or -blame, and resignation (Ferrando et al., 2004; Reissmann et al., 2012), compared to general population, while bruxers seem to use more positive coping strategies, like self-revalidation, -affirmation and situational control (Schneider et al., 2007; Soto-Goñi et al., 2020). Studies show differences on coping strategies in sleep and awake bruxism (Schneider et al., 2007; Soto Goñi et al., 202) and between genders (Schneider et al., 2007). Both bruxism and TMD patients could benefit from a positive coping strategy like AR. The present study showed that comorbid other pain, like NSPS and other pain sites, and TMD pain on masticatory muscle palpation in TMD patients decreased more during the 12-month follow-up in the AR group as compared to SS treatment. The pain on palpation continued to decrease in the AR group as opposed to the SS group; this refers to an increase in coping ability in the AR group. In the present study the effect of AR on bruxism was not an aim but it needs to be studied.

Treatment or change of behavioral mechanisms, such as parafunctions in TMD, is always a challenge for any therapist. Therefore, recognizing the reasons behind the person's harmful behavior is a good start, but information is needed in order to make progress. Both the patient and the therapist need positive feedback and motivation to willingly alter any behavior. Motivating energy is also needed in biofeedback and cognitive behavioral methods, such as AR, to achieve significant outcome. In both individual and group sessions of AR the feedback is implemented when any confronted problems with relaxation are talked through.

Occlusal devices and splints reduce the damage caused by sleep bruxism, but there is no evidence of significant reduction of phasic or tonic muscle activity which is more apparent in awake bruxism. Bruxism is considered to be centrally regulated and as AR may have an impact on autonomic nervous system it may also be effective on bruxism. However, muscle relaxation, risk-factor avoiding, and stress reducing assessments in bruxers have not been sufficiently studied in RCTs.

6.6 Considerations of methodology, strengths, and limitations

6.6.1 The surveys

The FSHS survey is internationally unique, and the data covers a representative cross-section of the Finnish student population at two time points, providing valuable information to the student health care professionals. The sampling was done systematically, and rich and equal representation of gender, age-group, and study level and field was achieved, which is a major strength of the study. To the best of our knowledge, most of the studies on students have involved dental or medical students who are more aware of the concept of bruxism and TMD, which may affect the reports.

The data collection for the FSHS survey was well designed, with experience of four earlier similar surveys. The study population samples of the FSHS surveys in 2012 and 2016 covered 3.6% and 4.8% of a 276 279 and 208 825 student population, respectively. The number of respondents was 4 408 in 2012 and 3 082 in 2016, which makes it one of the largest student populations studied, if not the largest. The age, gender, and university distributions were equal, as was the respondent distribution on a larger scale. Although a large study population and randomization decrease bias, the phenomenon of responding fatigue can be seen in this population, as has been noted in other studies (Tolonen et al., 2006). Population studies may include bias due to non-response, as young men are less active in responding to surveys than young women (Kunttu et al., 2017). Likewise, those who respond may often also be active in health maintenance, but also interested in their own condition. However, based on the bias analysis of the FSHS studies, the respondent group did not differ from those from the previous surveys in 2000, 2004, and 2008 (Kunttu et al., 2017). Also, a dropout analysis of an annual FSHS survey (Ritakorpi, Kaunonen, Kaila, Paldanius, & Seilo, 2019) showed that the main reasons for non-response were lack of time, interest or recollection of receiving the questionnaire, and experience of sufficiently good health. However, no difference between the dropouts and the respondents concerning physical or mental health was shown.

The response rate for all the questions used in the present study was good; more than 99% of the respondents answered the general health and GHQ-12 questions, and more than 98% answered the TMD-specific questions. Data for the present study was collected using validated questions for TMD (Lövgren et al., 2016) and distress (Goldberg et al., 1997), which have also been applied in other studies concerning TMD and distress (Tuuliainen et al., 2015). This is considered a strength in the study, as is using separate questions for AB, SB, and AB+SB. However, the modified definition of widespread pain in this study required only two pain areas, which is less than usually. A more accurate and wider understanding of widespread pain would be accomplished by assessing the ACR 2010/2011 (American College for Rheumatology) or the WPI (Widespread Pain Index) definitions with at least three or four pain areas, and on both sides of the body (Wolfe, Clauw, Fitzcharles, Goldenberg, Katz, Mease, … & Yunus, 2010; Wolfe, Egloff & Häuser, 2016). One major limitation of the FSHS survey concerning the present study is that the data is based on self-report. Therefore, bruxism is considered only as possible and may cause bias in the study. In the present study a lack of confirming questions such as "have you been told by your partner/roommate/dentist that you brux?" may cause underestimation. A clinical examination for a sample of the respondents would have given more reliable results; however, this is difficult to organize in a national population study. Earlier studies using polysomnography and electromyography have shown similar results of the association between TMD symptoms and bruxism (Raphael et al., 2013; Smardz et al., 2019).

6.6.2 The clinical trial

The study population of the RCT was gathered from FSHS health care patients who reported TMD-related symptoms. Most of the participants were women, which is in line with the gender distribution of prevalence studies and also indicates the tendency of women to seek treatment more easily. The age range was equal to the FSHS study population, which enables conjoining the results to a thesis. The RCT on the treatment effect of AR as compared to conventional SS was conducted on similar population as the survey, which strengthens the structure of the thesis.

The baseline questionnaire for the background factors of TMD was modified slightly with the addition of the questions on NSPS after the first thirty participants, which caused incomplete data collection. This was taken into consideration in the analysis, however.

The clinical TMD examinations were performed according to a modified DC/TMD clinical examination protocol. The dissimilarity to the confirmed DC/TMD clinical examination was the lack of determining muscle related sub-diagnoses. The examinations were performed by one educated dentist, which excludes the possibility for inter-examiner error.

Data on psychosocial background factors were collected according to the validated RDC/TMD Axis II questionnaires (Dworkin & Le Resche, 1992; Suvinen et al., 2010). Using the RDC/TMD questionnaire and DC/TMD-based clinical examination protocol is a strength in the present study as more specific diagnoses are reached than those according to ICD-10. Myalgia was diagnosed for 100% and arthralgia for 41% of the study patients. As the proportion of internal derangement of TMJ was lower, no conclusions can be drawn of the effect of AR on their treatment. TMD diagnoses were equally distributed between the groups, thus allowing comparisons. Also, the one-year follow-up period was a strength in the present study.

The large number of dropouts was a weakness in the present RCT study. The number of participants at each follow-up varied due to dropouts; most of them (29 subjects) dropped out after the baseline examination, which is in accordance with earlier studies, suggesting that information might be sufficient treatment for mild TMD cases (Aggarwal et al., 2019; Roldán-Barraza et al., 2014). Dropout is common in clinical studies; the significance of it varies depending on the reason (Bell, Kenward, Fairclough, & Horton, 2013). Dropouts in the present study population may be linked to study period and lack of time during studies. Furthermore, based on a dropout analysis (study III), no significant differences in gender, group status, the outcome variables (VAS on pain intensity, NSPS, and number of pain sites) were detected, except on values of VAS in the stabilization splint group at the 3-month follow-up. The dropouts may at least partially be related to pain relief at 3-month follow-up; those having less pain were more susceptible to drop out from the study. Thus, the dropouts may not be associated with gender or treatment, but rather, with other circumstances. A bias in the outcomes between groups may exist as the intention to treat analysis was not performed.

7 Summary and clinical implications

The present thesis discusses TMD and its background factors in a special Finnish population for the first time. The wide range of study fields and geographical coverage allows better comparability to general population than earlier studies with medical and dental students does. The present thesis shows the high prevalence of TMD symptoms and self-reported bruxism and their association with psychosocial background factors, such as distress, among the Finnish students. The increased psychological distress shown in student populations is a risk factor of TMD symptoms and bruxism which, as shown in the present study, are more common in student populations as compared to the general population. Also, pains beside TMD are common in young university students and associate with TMD pains and bruxism. In the long run, these factors contribute strongly to chronification of pain. To avoid an increase of chronic pain patients in health care it is important to study young adult populations and implement long-lasting treatment modalities like applied relaxation before chronification.

As over a quarter of the student population reported TMD pain and bruxism, which may significantly reduce their quality of life and cause disability, dentists need to react when diagnosing TMD and bruxism. All dentists should have the skills and tools for treatment of TMD, as well as opportunity for interdisciplinary co-operation in cases with widespread pain or increased psychosocial burden. The interdisciplinary possibilities in most parts of Finland are scarce and the challenge for TMD management is high. Thus, in the future, the preliminary results in the present thesis show that applied relaxation could be successful and implemented by any trained health personnel as one cost effective method to relieve musculoskeletal pain in basic health care on TMD patients with psychosocial burden. Additionally, while applied relaxation affects various psychological and pain symptoms, it also gives a person a skill for life that can be developed and used whenever needed in various pains or emotional situations.

Perspectives for future studies are

1. to assess the association of abdominal pain and stress-related diseases on TMD in students
2. to assess the effect of applied relaxation method on bruxism
3. to develop and test a digital applied relaxation-based application for tailored treatment of TMD

4. to assess the possible impact of COVID-19 pandemic lockdown on TMD symptoms and bruxism and their psychosocial background in Finnish students

8 Conclusions

The results of the present study indicate a high prevalence of TMD pain symptoms and self-reported bruxism in Finnish university students. TMD symptoms and bruxism are strongly associated with elevated distress and pain in other areas of the body. Students are at high risk of TMD-related pain syndrome with several background factors.

The present study showed for the first time that the cognitive behavioristically based applied relaxation method is a potential tool for treatment of TMD, especially in patients with psychosocial burden and other pains.

1. The prevalence of TMD symptoms and self-reported bruxism is higher as compared to general population, and TMD symptoms are reported twice as often by women as compared to men in Finnish university students
2. TMD symptoms and self-reported bruxism are mutually associated in Finnish university students
3. Psychological distress and weak widespread pain are associated with TMD symptoms and with bruxism in Finnish university students
4. AR treatment seems to relieve local TMD symptoms equally compared to SS but is more effective for alleviating general body symptoms, however, more well-designed RCTs are needed.

References

Aalto, A. M., Elovainio, M., Kivimäki, M., Uutela, A., & Pirkola, S. (2012). The Beck Depression Inventory and General Health Questionnaire as measures of depression in the general population: a validation study using the Composite International Diagnostic Interview as the gold standard. *Psychiatry Research, 197*(1-2), 163–171. https://doi.org/10.1016/j.psychres.2011.09.008

Abe, S., Yamaguchi, T., Rompré, P. H., De Grandmont, P., Chen, Y. J., & Lavigne, G. J. (2009). Tooth wear in young subjects: a discriminator between sleep bruxers and controls? *The International Journal of Prosthodontics, 22*(4), 342–350.

Aggarwal, V. R., Fu, Y., Main, C. J., & Wu, J. (2019). The effectiveness of self-management interventions in adults with chronic orofacial pain: A systematic review, meta-analysis and meta-regression. *European Journal of Pain (London, England), 23*(5), 849–865. https://doi.org/10.1002/ejp.1358

Aggarwal, V. R., Tickle, M., Javidi, H., & Peters, S. (2010). Reviewing the evidence: can cognitive behavioral therapy improve outcomes for patients with chronic orofacial pain? *Journal of Orofacial Pain, 24*(2), 163–171.

Ahlberg, J., Lobbezoo, F., Ahlberg, K., Manfredini, D., Hublin, C., Sinisalo, J., … Savolainen, A. (2013). Self-reported bruxism mirrors anxiety and stress in adults. *Medicina Oral, Patologia Oral Y Cirugia Bucal, 18*(1), e7–e11. https://doi.org/10.4317/medoral.18232

Ahlberg, J., Piirtola, M., Lobbezoo, F., Manfredini, D., Korhonen, T., Aarab, G., … Kaprio, J. (2020). Correlates and genetics of self-reported sleep and awake bruxism in a nationwide twin cohort. *Journal of Oral Rehabilitation, 47*(9), 1110–1119. https://doi.org/10.1111/joor.13042

Ahlberg, J., Savolainen, A., Rantala, M., Lindholm, H., & Könönen, M. (2004). Reported bruxism and biopsychosocial symptoms: a longitudinal study. *Community Dentistry and Oral Epidemiology, 32*(4), 307–311. https://doi.org/10.1111/j.1600-0528.2004.00163.x

Akhter, R., Morita, M., Ekuni, D., Hassan, N. M., Furuta, M., Yamanaka, R., Matsuka, Y., & Wilson, D. (2013). Self-reported aural symptoms, headache and temporomandibular disorders in Japanese young adults. *BMC Musculoskeletal Disorders, 14*, 58. https://doi.org/10.1186/1471-2474-14-58

Akhter, R., Morita, M., Esaki, M., Nakamura, K., & Kanehira, T. (2011). Development of temporomandibular disorder symptoms: a 3-year cohort study of university students. *Journal of Oral Rehabilitation, 38*(6), 395–403. https://doi.org/10.1111/j.1365-2842.2010.02195.x

Al-Moraissi, E. A., Farea, R., Qasem, K. A., Al-Wadeai, M. S., Al-Sabahi, M. E., & Al-Iryani, G. M. (2020). Effectiveness of occlusal splint therapy in the management of temporomandibular disorders: network meta-analysis of randomized controlled trials. *International Journal of Oral and Maxillofacial Surgery, 49*(8), 1042–1056. https://doi.org/10.1016/j.ijom.2020.01.004

Amorim, C., Espirito Santo, A. S., Sommer, M., & Marques, A. P. (2018). Effect of Physical Therapy in Bruxism Treatment: A Systematic Review. *Journal of Manipulative and Physiological Therapeutics, 41*(5), 389–404. https://doi.org/10.1016/j.jmpt.2017.10.014

Andersson G. (2002). Psychological aspects of tinnitus and the application of cognitive-behavioral therapy. *Clinical Psychology Review, 22*(7), 977–990. https://doi.org/10.1016/s0272-7358(01)00124-6

Andersson, G., Johansson, C., Nordlander, A., & Asmundson, G. J. (2012). Chronic pain in older adults: a controlled pilot trial of a brief cognitive-behavioural group treatment. *Behavioural and Cognitive Psychotherapy, 40*(2), 239–244. https://doi.org/10.1017/S1352465811000646

Armijo-Olivo, S., Pitance, L., Singh, V., Neto, F., Thie, N., & Michelotti, A. (2016). Effectiveness of Manual Therapy and Therapeutic Exercise for Temporomandibular Disorders: Systematic Review and Meta-Analysis. *Physical Therapy, 96*(1), 9–25. https://doi.org/10.2522/ptj.20140548

Armstrong, A., Knapp, V. M., & McAdam, D. B. (2014). Functional analysis and treatment of the diurnal bruxism of a 16-year-old girl with autism. *Journal of Applied Behavior Analysis, 47*(2), 415–419. https://doi.org/10.1002/jaba.122

Baad-Hansen, L., Thymi, M., Lobbezoo, F., & Svensson, P. (2019). To what extent is bruxism associated with musculoskeletal signs and symptoms? A systematic review. *Journal of Oral Rehabilitation, 46*(9), 845–861. https://doi.org/10.1111/joor.12821

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

Barnoy, E. L., Najdowski, A. C., Tarbox, J., Wilke, A. E., & Nollet, M. D. (2009). Evaluation of a multicomponent intervention for diurnal bruxism in a young child with autism. *Journal of Applied Behavior Analysis, 42*(4), 845–848. https://doi.org/10.1901/jaba.2009.42-845

Bawa, F. L., Mercer, S. W., Atherton, R. J., Clague, F., Keen, A., Scott, N. W., & Bond, C. M. (2015). Does mindfulness improve outcomes in patients with chronic pain? Systematic review and meta-analysis. *The British Journal of General Practice : The Journal of The Royal College of General Practitioners, 65*(635), e387–e400. https://doi.org/10.3399/bjgp15X685297

Bell, M. L., Kenward, M. G., Fairclough, D. L., & Horton, N. J. (2013). Differential dropout and bias in randomised controlled trials: when it matters and when it may not. *BMJ (Clinical Research Ed.), 346*, e8668. https://doi.org/10.1136/bmj.e8668

Berger, M., Szalewski, L., Bakalczuk, M., Bakalczuk, G., Bakalczuk, S., & Szkutnik, J. (2015). Association between estrogen levels and temporomandibular disorders: a systematic literature review. *Przeglad Menopauzalny = Menopause Review, 14*(4), 260–270. https://doi.org/10.5114/pm.2015.56538

Beukes, E. W., Manchaiah, V., Baguley, D. M., Allen, P. M., & Andersson, G. (2018). Process evaluation of Internet-based cognitive behavioural therapy for adults with tinnitus in the context of a randomised control trial. *International Journal of Audiology, 57*(2), 98–109. https://doi.org/10.1080/14992027.2017.1384858

Blanco Aguilera, A., Gonzalez Lopez, L., Blanco Aguilera, E., De la Hoz Aizpurua, J. L., Rodriguez Torronteras, A., Segura Saint-Gerons, R., & Blanco Hungría, A. (2014). Relationship between self-reported sleep bruxism and pain in patients with temporomandibular disorders. *Journal of Oral Rehabilitation, 41*(8), 564–572. https://doi.org/10.1111/joor.12172

Bracci, A., Djukic, G., Favero, L., Salmaso, L., Guarda-Nardini, L., & Manfredini, D. (2018). Frequency of awake bruxism behaviours in the natural environment. A 7-day, multiple-point observation of real-time report in healthy young adults. *Journal of Oral Rehabilitation, 45*(6), 423–429. https://doi.org/10.1111/joor.12627

Brancher, J. A., Bertoli, F., Michels, B., Lopes-Faturri, A., Pizzatto, E., Losso, E. M., … Wambier, L. M. (2021). Is catechol-O-methyltransferase gene associated with temporomandibular disorders? A systematic review and meta-analysis. *International Journal of Paediatric Dentistry, 31*(1), 152–163. https://doi.org/10.1111/ipd.12721

Buchholz, B., Kelly, J., Bernatene, E. A., Méndez Diodati, N., & Gelpi, R. J. (2017). Antagonistic and Synergistic Activation of Cardiovascular Vagal and Sympathetic Motor Outflows in Trigeminal Reflexes. *Frontiers In Neurology, 8*, 52. https://doi.org/10.3389/fneur.2017.00052

Calixtre, L. B., Moreira, R. F., Franchini, G. H., Alburquerque-Sendín, F., & Oliveira, A. B. (2015). Manual therapy for the management of pain and limited range of motion in subjects with signs and symptoms of temporomandibular disorder: a systematic review of randomised controlled trials. *Journal of Oral Rehabilitation, 42*(11), 847–861. https://doi.org/10.1111/joor.12321

Campbell, C. M., Kronfli, T., Buenaver, L. F., Smith, M. T., Berna, C., Haythornthwaite, J. A., & Edwards, R. R. (2010). Situational versus dispositional measurement of catastrophizing: associations with pain responses in multiple samples. *The Journal of Pain, 11*(5), 443–453.e2. https://doi.org/10.1016/j.jpain.2009.08.009

Carlbring, P., Ekselius, L., & Andersson, G. (2003). Treatment of panic disorder via the Internet: a randomized trial of CBT vs. applied relaxation. *Journal of Behavior Therapy and Experimental Psychiatry, 34*(2), 129–140. https://doi.org/10.1016/s0005-7916(03)00026-0

Carlson, C. R., Bertrand, P. M., Ehrlich, A. D., Maxwell, A. W., & Burton, R. G. (2001). Physical self-regulation training for the management of temporomandibular disorders. *Journal of Orofacial Pain, 15*(1), 47–55.

Carlsson G. E. (1999). Epidemiology and treatment need for temporomandibular disorders. *Journal of Orofacial Pain, 13*(4), 232–237.

Carra, M. C., Huynh, N., Morton, P., Rompré, P. H., Papadakis, A., Remise, C., & Lavigne, G. J. (2011). Prevalence and risk factors of sleep bruxism and wake-time tooth clenching in a 7- to 17-yr-old population. *European Journal of Oral Sciences, 119*(5), 386–394. https://doi.org/10.1111/j.1600-0722.2011.00846.x

Casett, E., Réus, J. C., Stuginski-Barbosa, J., Porporatti, A. L., Carra, M. C., Peres, M. A., … Manfredini, D. (2017). Validity of different tools to assess sleep bruxism: a meta-analysis. *Journal of Oral Rehabilitation, 44*(9), 722–734. https://doi.org/10.1111/joor.12520

Cavallo, P., Carpinelli, L., & Savarese, G. (2016). Perceived stress and bruxism in university students. *BMC Research Notes, 9*(1), 514. https://doi.org/10.1186/s13104-016-2311-0

Chantaracherd, P., John, M. T., Hodges, J. S., & Schiffman, E. L. (2015). Temporomandibular joint disorders' impact on pain, function, and disability. *Journal of Dental Research, 94*(3 Suppl), 79S–86S. https://doi.org/10.1177/0022034514565793

Ciancaglini, R., Gherlone, E. F., & Radaelli, G. (2001). The relationship of bruxism with craniofacial pain and symptoms from the masticatory system in the adult population. *Journal of Oral Rehabilitation, 28*(9), 842–848. https://doi.org/10.1046/j.1365-2842.2001.00753.x

Cieza, A., Causey, K., Kamenov, K., Hanson, S. W., Chatterji, S., & Vos, T. (2021). Global estimates of the need for rehabilitation based on the Global Burden of Disease study 2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet (London, England), 396*(10267), 2006–2017. https://doi.org/10.1016/S0140-6736(20)32340-0

Dahan, H., Shir, Y., Velly, A., & Allison, P. (2015). Specific and number of comorbidities are associated with increased levels of temporomandibular pain intensity and duration. *The Journal of Headache and Pain, 16*, 528. https://doi.org/10.1186/s10194-015-0528-2

de Baat, C., Verhoeff, M., Ahlberg, J., Manfredini, D., Winocur, E., Zweers, P., … Lobbezoo, F. (2021). Medications and addictive substances potentially inducing or attenuating sleep bruxism and/or awake bruxism. *Journal of Oral Rehabilitation, 48*(3), 343–354. https://doi.org/10.1111/joor.13061

de Leeuw, R., & Klasser, G. D. (editors). (2013). Orofacial pain guidelines for assessment, diagnosis, and management. 5th ed 2013. pp. 4–14. Quintessence Publishing

de Melo, L. A., Bezerra de Medeiros, A. K., Campos, M., Bastos Machado de Resende, C. M., Barbosa, G., & de Almeida, E. O. (2020). Manual Therapy in the Treatment of Myofascial Pain Related to Temporomandibular Disorders: A Systematic Review. *Journal of Oral & Facial Pain and Headache, 34*(2), 141–148. https://doi.org/10.11607/ofph.2530

de Oliveira, A. S., Dias, E. M., Contato, R. G., & Berzin, F. (2006). Prevalence study of signs and symptoms of temporomandibular disorder in Brazilian college students. *Brazilian Oral Research, 20*(1), 3–7. https://doi.org/10.1590/s1806-83242006000100002

Delgado de la Serna, P., Plaza-Manzano, G., Cleland, J., Fernández-de-Las-Peñas, C., Martín-Casas, P., & Díaz-Arribas, M. J. (2020). Effects of Cervico-Mandibular Manual Therapy in Patients with Temporomandibular Pain Disorders and Associated Somatic Tinnitus: A Randomized Clinical Trial. *Pain Medicine (Malden, Mass.), 21*(3), 613–624. https://doi.org/10.1093/pm/pnz278

Derogatis, L. R. (1994). Symptom Checklist 90-R: Administration, scoring, and procedures manual (3rd ed.) MN: National Computer Systems, Minneapolis.

Drangsholt, M., & LeResche, L. (1999). Temporomandibular disorder pain. In: Crombie IK (ed). Epidemiology of Pain. Seattle: IASP Press, 203–233.

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., 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.

Ehde, D. M., Dillworth, T. M., & Turner, J. A. (2014). Cognitive-behavioral therapy for individuals with chronic pain: efficacy, innovations, and directions for research. *The American Psychologist, 69*(2), 153–166. https://doi.org/10.1037/a0035747

Ekman, A., Rousu, J., Näpänkangas, R., Kuoppala, R., Raustia, A., & Sipilä, K. (2020). Association of self-reported bruxism with temporomandibular disorders - Northern Finland Birth Cohort (NFBC) 1966 study. *Cranio : The Journal of Craniomandibular Practice*, 1–6. Advance online publication. https://doi.org/10.1080/08869634.2020.1853306

Ella, B., Ghorayeb, I., Burbaud, P., & Guehl, D. (2017). Bruxism in Movement Disorders: A Comprehensive Review. *Journal of Prosthodontics : Official Journal of The American College of Prosthodontists, 26*(7), 599–605. https://doi.org/10.1111/jopr.12479

Emodi Perlman, A., Lobbezoo, F., Zar, A., Friedman Rubin, P., van Selms, M. K., & Winocur, E. (2016). Self-Reported bruxism and associated factors in Israeli adolescents. *Journal of Oral Rehabilitation, 43*(6), 443–450. https://doi.org/10.1111/joor.12391

Emodi-Perlman, A., Eli, I., Friedman-Rubin, P., Goldsmith, C., Reiter, S., & Winocur, E. (2012). Bruxism, oral parafunctions, anamnestic and clinical findings of temporomandibular disorders in children. *Journal of Oral Rehabilitation, 39*(2), 126–135. https://doi.org/10.1111/j.1365-2842.2011.02254.x

Emodi-Perlman, A., Eli, I., Smardz, J., Uziel, N., Wieckiewicz, G., Gilon, E., … Wieckiewicz, M. (2020). Temporomandibular Disorders and Bruxism Outbreak as a Possible Factor of Orofacial Pain Worsening during the COVID-19 Pandemic-Concomitant Research in Two Countries. *Journal of Clinical Medicine, 9*(10), 3250. https://doi.org/10.3390/jcm9103250

Fernandes, A. C., Duarte Moura, D. M., Da Silva, L., De Almeida, E. O., & Barbosa, G. (2017). Acupuncture in Temporomandibular Disorder Myofascial Pain Treatment: A Systematic Review. *Journal of Oral & Facial Pain and Headache, 31*(3), 225–232. https://doi.org/10.11607/ofph.1719

Ferrando, M., Andreu, Y., Galdón, M. J., Durá, E., Poveda, R., & Bagán, J. V. (2004). Psychological variables and temporomandibular disorders: distress, coping, and personality. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics, 98*(2), 153–160. https://doi.org/10.1016/j.tripleo.2003.12.030

Fillingim, R. B., Ohrbach, R., Greenspan, J. D., Knott, C., Diatchenko, L., Dubner, R., … 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

Fillingim, R. B., Ohrbach, R., Greenspan, J. D., Knott, C., Dubner, R., Bair, E., … Maixner, W. (2011). Potential psychosocial risk factors for chronic TMD: descriptive data and empirically identified domains from the OPPERA case-control study. *The Journal of Pain, 12*(11 Suppl), T46–T60. https://doi.org/10.1016/j.jpain.2011.08.007

Florjanski, W., Malysa, A., Orzeszek, S., Smardz, J., Olchowy, A., Paradowska-Stolarz, A., & Wieckiewicz, M. (2019). Evaluation of Biofeedback Usefulness in Masticatory Muscle Activity Management-A Systematic Review. *Journal of Clinical Medicine, 8*(6), 766. https://doi.org/10.3390/jcm8060766

Forssell, H., Kauko, T., Kotiranta, U., & Suvinen, T. (2017). Predictors for future clinically significant pain in patients with temporomandibular disorder: A prospective cohort study. *European Journal of Pain (London, England), 21*(1), 188–197. https://doi.org/10.1002/ejp.916

Ganslev, C. A., Storebø, O. J., Callesen, H. E., Ruddy, R., & Søgaard, U. (2020). Psychosocial interventions for conversion and dissociative disorders in adults. *The Cochrane Database of Systematic Reviews, 7*(7), CD005331. https://doi.org/10.1002/14651858.CD005331.pub3

Gil-Martínez, A., Paris-Alemany, A., López-de-Uralde-Villanueva, I., & La Touche, R. (2018). Management of pain in patients with temporomandibular disorder (TMD): challenges and solutions. *Journal of Pain Research, 11*, 571–587. https://doi.org/10.2147/JPR.S127950

Glaros, A. G., Kim-Weroha, N., Lausten, L., & Franklin, K. L. (2007). Comparison of habit reversal and a behaviorally-modified dental treatment for temporomandibular disorders: a pilot investigation. *Applied Psychophysiology and Biofeedback, 32*(3-4), 149–154. https://doi.org/10.1007/s10484-007-9039-5

Goldberg, D. P., Gater, R., Sartorius, N., Ustun, T. B., Piccinelli, M., Gureje, O., & Rutter, C. (1997). The validity of two versions of the GHQ in the WHO study of mental illness in general health care. *Psychological Medicine, 27*(1), 191–197. https://doi.org/10.1017/s0033291796004242

Gray, R., & Al-Ani, Z. (2010). Risk management in clinical practice. Part 8. Temporomandibular disorders. *British Dental Journal, 209*(9), 433–449. https://doi.org/10.1038/sj.bdj.2010.981

Grossman, P., Niemann, L., Schmidt, S., & Walach, H. (2004). Mindfulness-based stress reduction and health benefits. A meta-analysis. *Journal of Psychosomatic Research, 57*(1), 35–43. https://doi.org/10.1016/S0022-3999(03)00573-7

Häggman-Henrikson, B., Alstergren, P., Davidson, T., Högestätt, E. D., Östlund, P., Tranaeus, S., … List, T. (2017). Pharmacological treatment of oro-facial pain - health technology assessment including a systematic review with network meta-analysis. *Journal of Oral Rehabilitation, 44*(10), 800–826. https://doi.org/10.1111/joor.12539

Häggman-Henrikson, B., Bechara, C., Pishdari, B., Visscher, C. M., & Ekberg, E. (2020). Impact of Catastrophizing in Patients with Temporomandibular Disorders-A Systematic Review. *Journal of Oral & Facial Pain and Headache, 34*(4), 379–397. https://doi.org/10.11607/ofph.2637

Häggman-Henrikson, B., Liv, P., Ilgunas, A., Visscher, C. M., Lobbezoo, F., Durham, J., & Lövgren, A. (2020). Increasing gender differences in the prevalence and chronification of orofacial pain in the population. *Pain, 161*(8), 1768–1775. https://doi.org/10.1097/j.pain.0000000000001872

Hankins M. (2008). The reliability of the twelve-item general health questionnaire (GHQ-12) under realistic assumptions. *BMC Public Health, 8*, 355. https://doi.org/10.1186/1471-2458-8-355

Hayes-Skelton, S. A., Roemer, L., & Orsillo, S. M. (2013). A randomized clinical trial comparing an acceptance-based behavior therapy to applied relaxation for generalized anxiety disorder. *Journal of Consulting and Clinical Psychology, 81*(5), 761–773. https://doi.org/10.1037/a0032871

Headache Classification Committee of the International Headache Society (IHS) The International Classification of Headache Disorders, 3rd edition. (2018). *Cephalalgia : An International Journal of Headache, 38*(1), 1–211. https://doi.org/10.1177/0333102417738202

Hongxing, L., Astrøm, A. N., List, T., Nilsson, I. M., & Johansson, A. (2016). Prevalence of temporomandibular disorder pain in Chinese adolescents compared to an age-matched Swedish population. *Journal of Oral Rehabilitation, 43*(4), 241–248. https://doi.org/10.1111/joor.12366

Huotari, P., Aunio, M., Paavola, L., & Kallio, J. (2019). Passiivisesti vietetty ruutuaika ja sen sisällölliset muutokset sekä yhteydet fyysiseen aktiivisuuteen 7. luokalta 9. luokalle. *Liikunta ja Tiede, 56*(2-3), 84–89.

Huttunen, J., Qvintus, V., Suominen, A. L., & Sipilä, K. (2019). Role of psychosocial factors on treatment outcome of temporomandibular disorders. *Acta Odontologica Scandinavica, 77*(2), 119–125. https://doi.org/10.1080/00016357.2018.1511057

Jiménez-Silva, A., Peña-Durán, C., Tobar-Reyes, J., & Frugone-Zambra, R. (2017). Sleep and awake bruxism in adults and its relationship with temporomandibular disorders: A systematic review from 2003 to 2014. *Acta Odontologica Scandinavica, 75*(1), 36–58. https://doi.org/10.1080/00016357.2016.1247465

Jivnani, H. M., Tripathi, S., Shanker, R., Singh, B. P., Agrawal, K. K., & Singhal, R. (2019). A study to determine the prevalence of temporomandibular disorders in a young adult population and its association with psychological and functional occlusal parameters. *Journal of Prosthodontics, 28*(1), e445-e449. https://doi.org/10.1111/jopr.12704

Johansson, C., Dahl, J., Jannert, M., Melin, L., & Andersson, G. (1998). Effects of a cognitive-behavioral pain-management program. *Behaviour Research and Therapy, 36*(10), 915–930. https://doi.org/10.1016/s0005-7967(98)00079-5

Jussila, P., Kiviahde, H., Näpänkangas, R., Päkkilä, J., Pesonen, P., Sipilä, K., … 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

Jussila, P., Knuutila, J., Salmela, S., Näpänkangas, R., Päkkilä, J., Pirttiniemi, P., & Raustia, A. (2018). Association of risk factors with temporomandibular disorders in the Northern Finland Birth Cohort 1966. *Acta Odontologica Scandinavica, 76*(7), 525–529. https://doi.org/10.1080/00016357.2018.1479769

Kääpä, E. H., Frantsi, K., Sarna, S., & Malmivaara, A. (2006). Multidisciplinary group rehabilitation versus individual physiotherapy for chronic nonspecific low back pain: a randomized trial. *Spine, 31*(4), 371–376. https://doi.org/10.1097/01.brs.0000200104.90759.8c

Kaartinen, S., Aaltonen, S., Korhonen, T., Latvala, A., Mikkelsson, M., Kujala, U. M., & Kaprio, J. (2019). Is diversity of leisure-time sport activities associated with low back and neck-shoulder region pain? A Finnish twin cohort study. *Preventive Medicine Reports, 15*, 100933. https://doi.org/10.1016/j.pmedr.2019.100933

Kalla, R., Ventham, N. T., Satsangi, J., & Arnott, I. D. (2014). Crohn's disease. *BMJ (Clinical Research Ed.), 349*, g6670. https://doi.org/10.1136/bmj.g6670

Karabicak, G. O., & Hazar Kanik, Z. (2020). Temporomandibular disorder prevalence and its association with oral parafunctions, neck pain, and neck function in healthcare students: A cross-sectional study. *Cranio : The Journal of Craniomandibular Practice*, 1–7. Advance online publication. https://doi.org/10.1080/08869634.2020.1862581

Karaman, A., & Sapan, Z. (2020). Evaluation of temporomandibular disorders, quality of life, and oral habits among dentistry students. *Cranio : The Journal of Craniomandibular Practice*, 1–7. Advance online publication. https://doi.org/10.1080/08869634.2020.1857615

Karibe, H., Goddard, G., Shimazu, K., Kato, Y., Warita-Naoi, S., & Kawakami, T. (2014). Comparison of self-reported pain intensity, sleeping difficulty, and treatment outcomes of patients with myofascial temporomandibular disorders by age group: a prospective outcome study. *BMC Musculoskeletal Disorders, 15*, 423. https://doi.org/10.1186/1471-2474-15-423

Karthik, R., Hafila, M., Saravanan, C., Vivek, N., Priyadarsini, P., & Ashwath, B. (2017). Assessing Prevalence of Temporomandibular Disorders among University Students: A Questionnaire Study. *Journal of International Society of Preventive & Community Dentistry, 7*(Suppl 1), S24–S29. https://doi.org/10.4103/jispcd.JISPCD_146_17

Kemani, M. K., Hesser, H., Olsson, G. L., Lekander, M., & Wicksell, R. K. (2016). Processes of change in Acceptance and Commitment Therapy and Applied Relaxation for long-standing pain. *European Journal of Pain (London, England), 20*(4), 521–531. https://doi.org/10.1002/ejp.754

Kemani, M. K., Olsson, G. L., Lekander, M., Hesser, H., Andersson, E., & Wicksell, R. K. (2015). Efficacy and Cost-effectiveness of Acceptance and Commitment Therapy and Applied Relaxation for Longstanding Pain: A Randomized Controlled Trial. *The Clinical Journal of Pain, 31*(11), 1004–1016. https://doi.org/10.1097/AJP.0000000000000203

Khalid, S., & Tubbs, R. S. (2017). Neuroanatomy and Neuropsychology of Pain. *Cureus, 9*(10), e1754. https://doi.org/10.7759/cureus.1754

Khoury, B., Sharma, M., Rush, S. E., & Fournier, C. (2015). Mindfulness-based stress reduction for healthy individuals: A meta-analysis. *Journal of Psychosomatic Research, 78*(6), 519–528. https://doi.org/10.1016/j.jpsychores.2015.03.009

Kinalski, M. A., Cadermatori, M. G., Horta, B. L., Correa, M. B., Demarco, F. F., & Pereira-Cenci, T. (2019). Common mental disorders and bruxism in adults: a birth cohort study. *Journal of Dentistry, 83*, 27–32. https://doi.org/10.1016/j.jdent.2019.02.003

Klasser, G. D., & Greene, C. S. (2009). Oral appliances in the management of temporomandibular disorders. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics, 107*(2), 212–223. https://doi.org/10.1016/j.tripleo.2008.10.007

Köhler, 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

Koskinen, S., Kestilä, L., Martelin, T., Aromaa, A., eds. (2005). The health of young adults. Baseline results of the Health 2000 Study on the health of 18 to 29- year-olds and the factors associated with it. Publications of the National Public Health Institute B 7 / 2005. Helsinki 2005. Accessed April 24, 2021.

Kotiranta, U., Suvinen, T., & Forssell, H. (2014). Tailored treatments in temporomandibular disorders: where are we now? A systematic qualitative literature review. *Journal of Oral & Facial Pain and Headache, 28*(1), 28–37. https://doi.org/10.11607/jop.1121

Kunttu, K. & Pesonen, T. (2013). Student Health Survey 2012. A national survey among Finnish university students. Research publications of the Finnish Student Health Service 47. 2013. http://www.yths.fi/en/health_information_and_research/research_and_publications/the_finnish_health_survey (January 2020).

Kunttu, K., Pesonen, T., & Saari, J. (2017). Student Health Survey 2016. A national survey among Finnish university students. Research publications of the Finnish Student Health Service 48. 2017. http://www.yths.fi/en/health_information_and_research/research_and_publications/the_finnish_health_survey (January 2020).

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.

Lavigne, G. J., Khoury, S., Abe, S., Yamaguchi, T., & Raphael, K. (2008). Bruxism physiology and pathology: an overview for clinicians. *Journal of Oral Rehabilitation, 35*(7), 476–494. https://doi.org/10.1111/j.1365-2842.2008.01881.x

Lavigne, G. J., Rompré, P. H., & Montplaisir, J. Y. (1996). Sleep bruxism: validity of clinical research diagnostic criteria in a controlled polysomnographic study. *Journal of Dental Research, 75*(1), 546–552. https://doi.org/10.1177/00220345960750010601

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

Litt, M. D., Shafer, D. M., Ibanez, C. R., Kreutzer, D. L., & Tawfik-Yonkers, Z. (2009). Momentary pain and coping in temporomandibular disorder pain: exploring mechanisms of cognitive behavioral treatment for chronic pain. *Pain, 145*(1-2), 160–168. https://doi.org/10.1016/j.pain.2009.06.003

Lobbezoo, F., & Naeije, M. (2001). Bruxism is mainly regulated centrally, not peripherally. *Journal of Oral Rehabilitation, 28*(12), 1085–1091. https://doi.org/10.1046/j.1365-2842.2001.00839.x

Lobbezoo, F., Ahlberg, J., Glaros, A. G., Kato, T., Koyano, K., Lavigne, G. J., … & Winocur, E. (2013). Bruxism defined and graded: an international consensus. *Journal of Oral Rehabilitation, 40*(1), 2–4. https://doi.org/10.1111/joor.12011

Lobbezoo, F., Ahlberg, J., Manfredini, D., & Winocur, E. (2012). Are bruxism and the bite causally related?. *Journal of Oral Rehabilitation, 39*(7), 489–501. https://doi.org/10.1111/j.1365-2842.2012.02298.x

Lobbezoo, F., Ahlberg, J., Raphael, K. G., Wetselaar, P., Glaros, A. G., Kato, T., … Manfredini, D. (2018). International consensus on the assessment of bruxism: Report of a work in progress. *Journal of Oral Rehabilitation, 45*(11), 837–844. https://doi.org/10.1111/joor.12663

Lobbezoo, F., Visscher, C. M., Ahlberg, J., & Manfredini, D. (2014). Bruxism and genetics: a review of the literature. *Journal of Oral Rehabilitation, 41*(9), 709–714. https://doi.org/10.1111/joor.12177

Loster, J. E., Osiewicz, M. A., Groch, M., Ryniewicz, W., & Wieczorek, A. (2017). The Prevalence of TMD in Polish Young Adults. *Journal of Prosthodontics : Official Journal of The American College of Prosthodontists, 26*(4), 284–288. https://doi.org/10.1111/jopr.12414

Lövgren, A., Österlund, C., Ilgunas, A., Lampa, E., & Hellström, F. (2018). A high prevalence of TMD is related to somatic awareness and pain intensity among healthy dental students. *Acta Odontologica Scandinavica, 76*(6), 387–393. https://doi.org/10.1080/00016357.2018.1440322

Lövgren, A., Visscher, C. M., Häggman-Henrikson, B., Lobbezoo, F., Marklund, S., & Wänman, A. (2016). Validity of three screening questions (3Q/TMD) in relation to the DC/TMD. *Journal of Oral Rehabilitation, 43*(10), 729–736. https://doi.org/10.1111/joor.12428

Lung, J., Bell, L., Heslop, M., Cuming, S., & Ariyawardana, A. (2018). Prevalence of temporomandibular disorders among a cohort of university undergraduates in Australia. *Journal of Investigative and Clinical Dentistry, 9*(3), e12341. https://doi.org/10.1111/jicd.12341

Macedo, C. R., Macedo, E. C., Torloni, M. R., Silva, A. B., & Prado, G. F. (2014). Pharmacotherapy for sleep bruxism. *The Cochrane Database of Systematic Reviews*, (10), CD005578. https://doi.org/10.1002/14651858.CD005578.pub2

Magnusson, T., Adiels, A. M., Nilsson, H. L., & Helkimo, M. (2004). Treatment effect on signs and symptoms of temporomandibular disorders--comparison between stabilisation splint and a new type of splint (NTI). A pilot study. *Swedish Dental Journal, 28*(1), 11–20.

Magnusson, T., Egermark, I., & Carlsson, G. E. (2002). Treatment received, treatment demand, and treatment need for temporomandibular disorders in 35-year-old subjects. *Cranio: The Journal of Craniomandibular Practice, 20*(1), 11–17. https://doi.org/10.1080/08869634.2002.11746184

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

Maixner, W., Greenspan, J. D., Dubner, R., Bair, E., Mulkey, F., Miller, V., … Fillingim, R. B. (2011). Potential autonomic risk factors for chronic TMD: descriptive data and empirically identified domains from the OPPERA case-control study. *The Journal of Pain, 12*(11 Suppl), T75–T91. https://doi.org/10.1016/j.jpain.2011.09.002

Manfredini, D., & Lobbezoo, F. (2010). Relationship between bruxism and temporomandibular disorders: a systematic review of literature from 1998 to 2008. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics, 109*(6), e26–e50. https://doi.org/10.1016/j.tripleo.2010.02.013

Manfredini, D., Ahlberg, J., Winocur, E., & Lobbezoo, F. (2015). Management of sleep bruxism in adults: a qualitative systematic literature review. *Journal of Oral Rehabilitation, 42*(11), 862–874. https://doi.org/10.1111/joor.12322

Manfredini, D., Landi, N., Fantoni, F., Segù, M., & Bosco, M. (2005). Anxiety symptoms in clinically diagnosed bruxers. *Journal of Oral Rehabilitation, 32*(8), 584–588. https://doi.org/10.1111/j.1365-2842.2005.01462.x

Manfredini, D., Piccotti, F., Ferronato, G., & Guarda-Nardini, L. (2010). Age peaks of different RDC/TMD diagnoses in a patient population. *Journal of Dentistry, 38*(5), 392–399. https://doi.org/10.1016/j.jdent.2010.01.006

Manfredini, D., Serra-Negra, J., Carboncini, F., & Lobbezoo, F. (2017). Current Concepts of Bruxism. *The International Journal of Prosthodontics, 30*(5), 437–438. https://doi.org/10.11607/ijp.5210

Manfredini, D., Winocur, E., Guarda-Nardini, L., Paesani, D., & Lobbezoo, F. (2013). Epidemiology of bruxism in adults: a systematic review of the literature. *Journal of Orofacial Pain, 27*(2), 99–110. https://doi.org/10.11607/jop.921

Marhold, C., Linton, S. J., & Melin, L. (2001). A cognitive-behavioral return-to-work program: effects on pain patients with a history of long-term versus short-term sick leave. *Pain, 91*(1-2), 155–163. https://doi.org/10.1016/s0304-3959(00)00431-0

McCracken, L. M., & Vowles, K. E. (2014). Acceptance and commitment therapy and mindfulness for chronic pain: model, process, and progress. *The American Psychologist, 69*(2), 178–187. https://doi.org/10.1037/a0035623

Medeiros, R. A., Vieira, D. L., Silva, E., Rezende, L., Santos, R., & Tabata, L. F. (2020). Prevalence of symptoms of temporomandibular disorders, oral behaviors, anxiety, and depression in Dentistry students during the period of social isolation due to COVID-19. *Journal of Applied Oral Science: Revista FOB, 28*, e20200445. https://doi.org/10.1590/1678-7757-2020-0445

Medical Dictionary. Free Dictionary by Farlex. https://medical-dictionary.thefreedictionary.com

Michelotti, A., Cioffi, I., Festa, P., Scala, G., & Farella, M. (2010). Oral parafunctions as risk factors for diagnostic TMD subgroups. *Journal of Oral Rehabilitation, 37*(3), 157–162. https://doi.org/10.1111/j.1365-2842.2009.02033.x

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

Miettinen, O., Kämppi, A., Tanner, T., Anttonen, V., Patinen, P., Päkkilä, J., … 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

Miettinen, T., Myllymaa, K., Westeren-Punnonen, S., Ahlberg, J., Hukkanen, T., Toyras, J., … & Myllymaa, S. (2018). Success Rate and Technical Quality of Home Polysomnography With Self-Applicable Electrode Set in Subjects With Possible Sleep Bruxism. *IEEE Journal of Biomedical and Health Informatics, 22*(4), 1124–1132. https://doi.org/10.1109/JBHI.2017.2741522

Mishra, K. D., Gatchel, R. J., & Gardea, M. A. (2000). The relative efficacy of three cognitive-behavioral treatment approaches to temporomandibular disorders. *Journal of Behavioral Medicine, 23*(3), 293–309. https://doi.org/10.1023/a:1005562126071

Monaco, A., Cattaneo, R., Marci, M. C., Pietropaoli, D., & Ortu, E. (2017). Central Sensitization-Based Classification for Temporomandibular Disorders: A Pathogenetic Hypothesis. *Pain Research & Management, 2017*, 5957076. https://doi.org/10.1155/2017/5957076

Morell G. C. (2016). Manual therapy improved signs and symptoms of temporomandibular disorders. *Evidence-Based Dentistry, 17*(1), 25–26. https://doi.org/10.1038/sj.ebd.6401155

Muzalev, K., van Selms, M. K., & Lobbezoo, F. (2018). No Dose-Response Association Between Self-Reported Bruxism and Pain-Related Temporomandibular Disorders: A Retrospective Study. *Journal of Oral & Facial Pain and Headache, 32*(4), 375–380. https://doi.org/10.11607/ofph.2090

Nahit, E. S., Pritchard, C. M., Cherry, N. M., Silman, A. J., & Macfarlane, G. J. (2001). The influence of work related psychosocial factors and psychological distress on regional musculoskeletal pain: a study of newly employed workers. *The Journal of Rheumatology, 28*(6), 1378–1384.

National Institute of Dental and Craniofacial Research [7/28/2013] Facial Pain. http://www.nidcr.nih.gov/DataStatistics/FindDataByTopic/FacialPain/

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.

Nilsson, I. M., List, T., & Drangsholt, M. (2013). Headache and co-morbid pains associated with TMD pain in adolescents. *Journal of Dental Research, 92*(9), 802–807. https://doi.org/10.1177/0022034513496255

Niskanen, M., Hietaharju, M., Näpänkangas, R., Suvinen, T., & Sipilä, K. (2021). Association between self-reported symptoms of temporomandibular disorders and psychological distress in Finnish dental students. *Suomen Hammaslääkärilehti, 21*(5), 24–31.

Nogueira Coutinho, E., MPH, Pereira Rodrigues Dos Santos, K., MPH, Henrique Barros Ferreira, E., MPH, Grailea Silva Pinto, R., BHS, & de Oliveira Sanchez, M., DPH (2020). Association between self-reported sleep bruxism and temporomandibular disorder in undergraduate students from Brazil. *Cranio: The Journal of Craniomandibular Practice, 38*(2), 91–98. https://doi.org/10.1080/08869634.2018.1495874

Nomura, K., Vitti, M., Oliveira, A. S., Chaves, T. C., Semprini, M., Siéssere, S., … Regalo, S. C. (2007). Use of the Fonseca's questionnaire to assess the prevalence and severity of temporomandibular disorders in Brazilian dental undergraduates. *Brazilian Dental Journal, 18*(2), 163–167. https://doi.org/10.1590/s0103-64402007000200015

Odgers, C. L., & Jensen, M. R. (2020). Annual Research Review: Adolescent mental health in the digital age: facts, fears, and future directions. *Journal of Child Psychology and Psychiatry, and Allied Disciplines, 61*(3), 336–348. https://doi.org/10.1111/jcpp.13190

Ohrbach R, editor. Diagnostic Criteria for Temporomandibular Disorders: Assessment Instruments. Version 15May2016. [Diagnostiset Kriteerit Purentaelimistön Kivuille ja Toimintahäiriöille (DC/TMD-FIN): Tutkimusinstrumentit: Finnish Version 25May2016] Sipilä K, Suvinen T, Trans. www.rdc-tmdinternational.org. Accessed on 8June2020

Ohrbach, R., & Dworkin, S. F. (1998). Five-year outcomes in TMD: relationship of changes in pain to changes in physical and psychological variables. *Pain, 74*(2-3), 315–326. https://doi.org/10.1016/s0304-3959(97)00194-2

Ohrbach, R., & Dworkin, S. F. (2016). The Evolution of TMD Diagnosis: Past, Present, Future. *Journal of Dental Research, 95*(10), 1093–1101. https://doi.org/10.1177/0022034516653922

Ohrbach, R., Fillingim, R. B., Mulkey, F., Gonzalez, Y., Gordon, S., Gremillion, H., & Slade, G. (2011). Clinical findings and pain symptoms as potential risk factors for chronic TMD: descriptive data and empirically identified domains from the OPPERA case-control study. *The Journal of Pain, 12*(11 Suppl), T27–T45. https://doi.org/10.1016/j.jpain.2011.09.001

Ohrbach, R., Gonzalez, Y., Michelotti, A., & Schiffman, E. (2018). Diagnostic criteria for temporomandibular disorders (DC/TMD) clinical examination protocol: version 02June2013. [Diagnostiset kriteerit purentaelimistön kivuille ja toimintahäiriöille (DC/TMD - FIN): Tutkimusinstrumentit: Finnish version 02June2013]. Sipilä K, Suvinen T, Trans. www.rdc-tmdinternational.org .Accessed on December 19, 2018.

Ohrbach, R., Sharma, S., Fillingim, R. B., Greenspan, J. D., Rosen, J. D., & Slade, G. D. (2020). Clinical Characteristics of Pain Among Five Chronic Overlapping Pain Conditions. *Journal of Oral & Facial Pain and Headache, 34*, s29–s42. https://doi.org/10.11607/ofph.2573

Okeson, J. P. (2020). Management of Temporomandibular disorders 2020. 8th edition. St Louis, Elsevier, Inc.

Oksanen, A. M., Laimi, K., Löyttyniemi, E., & Kunttu, K. (2014). Trends of weekly musculoskeletal pain from 2000 to 2012: National study of Finnish university students. *European Journal of Pain (London, England), 18*(9), 1316–1322. https://doi.org/10.1002/j.1532-2149.2014.492.x

Oksanen, A., Laimi, K., Björklund, K., Löyttyniemi, E., & Kunttu, K. (2017). A 12-year Trend of Psychological Distress: National Study of Finnish University Students. *Central European Journal of Public Health, 25*(2), 113–119. https://doi.org/10.21101/cejph.a4438

Olivo, S. A., Fuentes, J., Major, P. W., Warren, S., Thie, N. M., & Magee, D. J. (2010). The association between neck disability and jaw disability. *Journal of Oral Rehabilitation, 37*(9), 670–679. https://doi.org/10.1111/j.1365-2842.2010.02098.x

Ommerborn, M. A., Schneider, C., Giraki, M., Schäfer, R., Handschel, J., Franz, M., & Raab, W. H. (2007). Effects of an occlusal splint compared with cognitive-behavioral treatment on sleep bruxism activity. *European Journal of Oral Sciences, 115*(1), 7–14. https://doi.org/10.1111/j.1600-0722.2007.00417.x

Öst, L. G. (1987). Applied relaxation: description of a coping technique and review of controlled studies. *Behaviour Research and Therapy, 25*(5), 397–409. https://doi.org/10.1016/0005-7967(87)90017-9

Öst, L. G., & Breitholtz, E. (2000). Applied relaxation vs. cognitive therapy in the treatment of generalized anxiety disorder. *Behaviour Research and Therapy, 38*(8), 777–790. https://doi.org/10.1016/s0005-7967(99)00095-9

Öst, L. G., & Westling, B. E. (1995). Applied relaxation vs cognitive behavior therapy in the treatment of panic disorder. *Behaviour Research and Therapy, 33*(2), 145–158. https://doi.org/10.1016/0005-7967(94)e0026-f

Owczarec, J. E., Lion, K. M., & Radwan-Oczko, M. (2020). The impact of stress, anxiety, and depression on stomatognathic system of physiotherapy and dentistry first-year students. *Brain and Behavior, 10*(10), e01797. https://doi.org/10.1002/brb3.1797

Paço, M., Peleteiro, B., Duarte, J., & Pinho, T. (2016). The Effectiveness of Physiotherapy in the Management of Temporomandibular Disorders: A Systematic Review and Meta-analysis. *Journal of Oral & Facial Pain and Headache, 30*(3), 210–220. https://doi.org/10.11607/ofph.1661

Paesani, D. A., Lobbezoo, F., Gelos, C., Guarda-Nardini, L., Ahlberg, J., & Manfredini, D. (2013). Correlation between self-reported and clinically based diagnoses of bruxism in temporomandibular disorders patients. *Journal of Oral Rehabilitation, 40*(11), 803–809. https://doi.org/10.1111/joor.12101

Patala, S., Näpänkangas, R., Sipilä, K. (2021). Sleep and awake bruxism and psychological distress in dental students. *Lääkärilehti, 76*(8), 29–37. www.laakarilehti.fi/english

Paulino, M. R., Moreira, V. G., Lemos, G. A., Silva, P., Bonan, P., & Batista, A. (2018). Prevalence of signs and symptoms of temporomandibular disorders in college preparatory students: associations with emotional factors, parafunctional habits, and impact on quality of life. Prevalência de sinais e sintomas de disfunção temporomandibular em estudantes pré-vestibulandos: associação de fatores emocionais, hábitos parafuncionais e impacto na qualidade de vida. *Ciencia & Saude Coletiva, 23*(1), 173–186. https://doi.org/10.1590/1413-81232018231.18952015

Phuong, N., Ngoc, V., Linh, L. M., Duc, N. M., Tra, N. T., & Anh, L. Q. (2020). Bruxism, Related Factors and Oral Health-Related Quality of Life Among Vietnamese Medical Students. *International Journal of Environmental Research and Public Health, 17*(20), 7408. https://doi.org/10.3390/ijerph17207408

Plesh, O., Adams, S. H., & Gansky, S. A. (2011). Temporomandibular joint and muscle disorder-type pain and comorbid pains in a national US sample. *Journal of Orofacial Pain, 25*(3), 190–198.

Plews-Ogan, M., Owens, J. E., Goodman, M., Wolfe, P., & Schorling, J. (2005). A pilot study evaluating mindfulness-based stress reduction and massage for the management of chronic pain. *Journal of General Internal Medicine, 20*(12), 1136–1138. https://doi.org/10.1111/j.1525-1497.2005.0247.x

Polmann, H., Réus, J. C., Massignan, C., Serra-Negra, J. M., Dick, B. D., Flores-Mir, C., … De Luca Canto, G. (2021). Association between sleep bruxism and stress symptoms in adults: A systematic review and meta-analysis. *Journal of Oral Rehabilitation, 48*(5), 621–631. https://doi.org/10.1111/joor.13142

Pontes, L., & Prietsch, S. (2019). Sleep bruxism: population based study in people with 18 years or more in the city of Rio Grande, Brazil. Bruxismo do sono: estudo de base populacional em pessoas com 18 anos ou mais na cidade de Rio Grande, Rio Grande do Sul. *Revista Brasileira De Epidemiologia = Brazilian Journal of Epidemiology, 22*, e190038. https://doi.org/10.1590/1980-549720190038

Quinelato, V., Bonato, L. L., Vieira, A. R., Granjeiro, J. M., Tesch, R., & Casado, P. L. (2018). Association Between Polymorphisms in the Genes of Estrogen Receptors and the Presence of Temporomandibular Disorders and Chronic Arthralgia. *Journal of Oral and Maxillofacial Surgery : Official Journal of The American Association of Oral and Maxillofacial Surgeons, 76*(2), 314.e1–314.e9. https://doi.org/10.1016/j.joms.2017.10.023

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., Nissinen, M., Lindholm, H., Savolainen, A., & Könönen, M. (2003). Temporomandibular joint related painless symptoms, orofacial pain, neck pain, headache, and psychosocial factors among non-patients. *Acta Odontologica Scandinavica, 61*(4), 217–222. https://doi.org/10.1080/00016350310004089

Raphael, K. G., Janal, M. N., Sirois, D. A., Dubrovsky, B., Wigren, P. E., Klausner, J. J., … Lavigne, G. J. (2013). Masticatory muscle sleep background electromyographic activity is elevated in myofascial temporomandibular disorder patients. *Journal of Oral Rehabilitation, 40*(12), 883–891. https://doi.org/10.1111/joor.12112

Raphael, K. G., Santiago, V., & Lobbezoo, F. (2016). Is bruxism a disorder or a behaviour? Rethinking the international consensus on defining and grading of bruxism. *Journal of Oral Rehabilitation, 43*(10), 791–798. https://doi.org/10.1111/joor.12413

Reissmann, D. R., John, M. T., Schierz, O., Seedorf, H., & Doering, S. (2012). Stress-related adaptive versus maladaptive coping and temporomandibular disorder pain. *Journal of Orofacial Pain, 26*(3), 181–190.

Ridner S. H. (2004). Psychological distress: concept analysis. *Journal of Advanced Nursing, 45*(5), 536–545. https://doi.org/10.1046/j.1365-2648.2003.02938.x

Riley, P., Glenny, A. M., Worthington, H. V., Jacobsen, E., Robertson, C., Durham, J., … Boyers, D. (2020). Oral splints for patients with temporomandibular disorders or bruxism: a systematic review and economic evaluation. *Health Technology Assessment (Winchester, England), 24*(7), 1–224. https://doi.org/10.3310/hta24070

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

Ritakorpi, M., Kaunonen, M., Kaila, M., Paldanius, S. & Seilo, N. (2019) Sähköiseen terveyskyselyyn vastaamatta jääneet yliopisto-opiskelijat – katoanalyysi. *Sosiaalilääketieteellinen Aikakauslehti, 56*(1). https://doi.org/10.23990/sa.70440.

Rocha, C. O., Peixoto, R. F., Resende, C. M., Alves, A. C., Oliveira, Â. G., & Barbosa, G. A. (2017). Psychosocial aspects and temporomandibular disorders in dental students. *Quintessence International (Berlin, Germany : 1985), 48*(3), 241–249. https://doi.org/10.3290/j.qi.a37128

Roldán-Barraza, C., Janko, S., Villanueva, J., Araya, I., & Lauer, H. C. (2014). A systematic review and meta-analysis of usual treatment versus psychosocial interventions in the treatment of myofascial temporomandibular disorder pain. *Journal of Oral & Facial Pain and Headache, 28*(3), 205–222. https://doi.org/10.11607/ofph.1241

Roy, R., de la Vega, R., Jensen, M. P., & Miró, J. (2020). Neurofeedback for Pain Management: A Systematic Review. *Frontiers In Neuroscience, 14*, 671. https://doi.org/10.3389/fnins.2020.00671

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.

Ryalat, S., Baqain, Z. H., Amin, W. M., Sawair, F., Samara, O., & Badran, D. H. (2009). Prevalence of temporomandibular joint disorders among students of the university of jordan. *Journal of Clinical Medicine Research, 1*(3), 158–164. https://doi.org/10.4021/jocmr2009.06.1245

Saczuk, K., Lapinska, B., Wilmont, P., Pawlak, L., & Lukomska-Szymanska, M. (2019). Relationship between Sleep Bruxism, Perceived Stress, and Coping Strategies. *International Journal of Environmental Research and Public Health, 16*(17), 3193. https://doi.org/10.3390/ijerph16173193

Sanders, A. E., Slade, G. D., Bair, E., Fillingim, R. B., Knott, C., Dubner, R., … Ohrbach, R. (2013). General health status and incidence of first-onset temporomandibular disorder: the OPPERA prospective cohort study. *The Journal of Pain, 14*(12 Suppl), T51–T62. https://doi.org/10.1016/j.jpain.2013.06.001

Sanders, A., Jain, D., Sofer, T., Kerr, K., Laurie, C., Shaffer, J., … Smith, S. (2017). GWAS Identifies New Loci for Painful Temporomandibular Disorder: Hispanic Community Health Study/Study of Latinos. *Journal of Dental Research, 96*(3), 277–284. https://doi.org/10.1177/0022034516686562

Schiffman, E. (2010). Diagnostic algorithms for TMJ disorders. Diagnostic criteria for TMD (DC/TMD): a new version of the RDC/TMD. *Journal of Dental Research, 89* (Spec Iss B), no. 1954.

Schiffman, E., Ohrbach, R., Truelove, E., Look, J., Anderson, G., Goulet, J. P., … 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

Schneider, C., Schaefer, R., Ommerborn, M. A., Giraki, M., Goertz, A., Raab, W. H., & Franz, M. (2007). Maladaptive coping strategies in patients with bruxism compared to non-bruxing controls. *International Journal of Behavioral Medicine, 14*(4), 257–261. https://doi.org/10.1007/BF03003001

Schumer, M. C., Lindsay, E. K., & Creswell, J. D. (2018). Brief mindfulness training for negative affectivity: A systematic review and meta-analysis. *Journal of Consulting and Clinical Psychology, 86*(7), 569–583. https://doi.org/10.1037/ccp0000324

Sendra, L. A., Montez, C., Vianna, K. C., & Barboza, E. P. (2020). Clinical outcomes of botulinum toxin type A injections in the management of primary bruxism in adults: A systematic review. *The Journal of Prosthetic Dentistry*, S0022-3913(20)30359-0. Advance online publication. https://doi.org/10.1016/j.prosdent.2020.06.002

Shah, N., Melo, L., Reid, W. D., & Cioffi, I. (2019). Masseter Deoxygenation in Adults at Risk for Temporomandibular Disorders. *Journal of Dental Research, 98*(6), 666–672. https://doi.org/10.1177/0022034519837249

Shimada, A., Ishigaki, S., Matsuka, Y., Komiyama, O., Torisu, T., Oono, Y., … Sasaki, K. (2019). Effects of exercise therapy on painful temporomandibular disorders. *Journal of Oral Rehabilitation, 46*(5), 475–481. https://doi.org/10.1111/joor.12770

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., Suominen, A. L., Alanen, P., Heliövaara, M., Tiittanen, P., & Könönen, M. (2011). Association of clinical findings of temporomandibular disorders (TMD) with self-reported musculoskeletal pains. *European Journal of Pain (London, England), 15*(10), 1061–1067. https://doi.org/10.1016/j.ejpain.2011.05.001

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., Ohrbach, R., Greenspan, J. D., Fillingim, R. B., Bair, E., Sanders, A. E., … 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., Ohrbach, R., Bair, E., Maixner, W., Greenspan, J. D., … Diatchenko, L. (2015). COMT Diplotype Amplifies Effect of Stress on Risk of Temporomandibular Pain. *Journal of Dental Research, 94*(9), 1187–1195. https://doi.org/10.1177/0022034515595043

Slade, G. D., Sanders, A. E., Ohrbach, R., Fillingim, R. B., Dubner, R., Gracely, R. H., … Greenspan, J. D. (2014). Pressure pain thresholds fluctuate with, but do not usefully predict, the clinical course of painful temporomandibular disorder. *Pain, 155*(10), 2134–2143. https://doi.org/10.1016/j.pain.2014.08.007

Slade, G. D., Smith, S. B., Zaykin, D. V., Tchivileva, I. E., Gibson, D. G., Yuryev, A., … Diatchenko, L. (2013). Facial pain with localized and widespread manifestations: separate pathways of vulnerability. *Pain, 154*(11), 2335–2343. https://doi.org/10.1016/j.pain.2013.07.009

Smardz, J., Martynowicz, H., Michalek-Zrabkowska, M., Wojakowska, A., Mazur, G., Winocur, E., & Wieckiewicz, M. (2019). Sleep Bruxism and Occurrence of Temporomandibular Disorders-Related Pain: A Polysomnographic Study. *Frontiers In Neurology, 10*, 168. https://doi.org/10.3389/fneur.2019.00168

Smiljic, S., Savic, S., Stevanovic, J., & Kostic, M. (2016). Prevalence and characteristics of orofacial pain in university students. *Journal of Oral Science, 58*(1), 7–13. https://doi.org/10.2334/josnusd.58.7

Smith, S. B., Maixner, D. W., Greenspan, J. D., Dubner, R., Fillingim, R. B., Ohrbach, R., … Diatchenko, L. (2011). Potential genetic risk factors for chronic TMD: genetic associations from the OPPERA case control study. *The Journal of Pain, 12*(11 Suppl), T92–T101. https://doi.org/10.1016/j.jpain.2011.08.005

Smith, S. B., Mir, E., Bair, E., Slade, G. D., Dubner, R., Fillingim, R. B., … Diatchenko, L. (2013). Genetic variants associated with development of TMD and its intermediate phenotypes: the genetic architecture of TMD in the OPPERA prospective cohort study. *The Journal of Pain, 14*(12 Suppl), T91–101.e1013. https://doi.org/10.1016/j.jpain.2013.09.004

Soares, L. G., Costa, I. R., Brum Júnior, J., Cerqueira, W., Oliveira, E. S., Douglas de Oliveira, D. W., … Flecha, O. D. (2017). Prevalence of bruxism in undergraduate students. *Cranio: The Journal of Craniomandibular Practice, 35*(5), 298–303. https://doi.org/10.1080/08869634.2016.1218671

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

Sojka, A., Żarowski, M., Steinborn, B., Hedzelek, W., Wiśniewska-Spychała, B., & Dorocka-Bobkowska, B. (2018). Temporomandibular disorders in adolescents with headache. *Advances In Clinical and Experimental Medicine : Official Organ Wroclaw Medical University, 27*(2), 193–199. https://doi.org/10.17219/acem/64945

Soto-Goñi, X. A., Alen, F., Buiza-González, L., Marcolino-Cruz, D., Sánchez-Sánchez, T., Ardizone-García, I., … Jiménez-Ortega, L. (2020). Adaptive Stress Coping in Awake Bruxism. *Frontiers In Neurology, 11*, 564431. https://doi.org/10.3389/fneur.2020.564431

Stallman, H. (2010). Psychological distress in university students: A comparison with general population data. *Australian Psychologist, 45*(4), 249–257. https://doi.org/10.1080/00050067.2010.482109

statista.com/statistics/565628/time-spent-digital-traditional media-usa

Storm Mienna, C., Glas, L., Magnusson, M., Ilgunas, A., Häggman-Henrikson, B., & Wänman, A. (2019). Patients' experiences of supervised jaw-neck exercise among patients with localized TMD pain or TMD pain associated with generalized pain. *Acta Odontologica Scandinavica, 77*(7), 495–501. https://doi.org/10.1080/00016357.2019.1598573

Stowell, A. W., Gatchel, R. J., & Wildenstein, L. (2007). Cost-effectiveness of treatments for temporomandibular disorders: biopsychosocial intervention versus treatment as usual. *Journal of The American Dental Association (1939), 138*(2), 202–208. https://doi.org/10.14219/jada.archive.2007.0137

Ström, L., Pettersson, R., & Andersson, G. (2000). A controlled trial of self-help treatment of recurrent headache conducted via the Internet. *Journal of Consulting and Clinical Psychology, 68*(4), 722–727.

Stuckler, D., Basu, S., Suhrcke, M., Coutts, A., & McKee, M. (2009). The public health effect of economic crises and alternative policy responses in Europe: an empirical analysis. *Lancet (London, England), 374*(9686), 315–323. https://doi.org/10.1016/S0140-6736(09)61124-7

Stuginski-Barbosa, J., Porporatti, A. L., Costa, Y. M., Svensson, P., & Conti, P. C. (2017). Agreement of the International Classification of Sleep Disorders Criteria with polysomnography for sleep bruxism diagnosis: A preliminary study. *The Journal of Prosthetic Dentistry, 117*(1), 61–66.

Suvinen, T. I., Nyström, M., Evälahti, M., Kleemola-Kujala, E., Waltimo, A., & Könönen, M. (2004). An 8-year follow-up study of temporomandibular disorder and psychosomatic symptoms from adolescence to young adulthood. *Journal of Orofacial Pain, 18*(2), 126–130.

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

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

Suvisaari, J., Ahola, K., Kiviruusu, O., Korkeila, J., Lindfors O, Mattila A, … Viertiö S. (2012) in Koskinen, Lundqvist, Ristiluoma (eds). Terveys, toimintakyky ja hyvinvointi Suomessa 2011. *Report of The National Public Health Institute 68*/2012. pp. 97–100. Juvenes Print – Suomen yliopistopaino Oy. Tampere. Accessed April 24, 2021.

Suzuki, S., Castrillon, E. E., Arima, T., Kitagawa, Y., & Svensson, P. (2016). Blood oxygenation of masseter muscle during sustained elevated muscle activity in healthy participants. *Journal of Oral Rehabilitation, 43*(12), 900–910. https://doi.org/10.1111/joor.12450

Tecco, S., Festa, F., Salini, V., Epifania, E., & D'Attilio, M. (2004). Treatment of joint pain and joint noises associated with a recent TMJ internal derangement: a comparison of an anterior repositioning splint, a full-arch maxillary stabilization splint, and an untreated control group. *Cranio: The Journal of Craniomandibular Practice, 22*(3), 209–219. https://doi.org/10.1179/crn.2004.026

Testa, M. A., & Simonson, D. C. (1996). Assessment of quality-of-life outcomes. *The New England Journal of Medicine, 334*(13), 835–840. https://doi.org/10.1056/NEJM199603283341306

Thorsell, J., Finnes, A., Dahl, J., Lundgren, T., Gybrant, M., Gordh, T., & Buhrman, M. (2011). A comparative study of 2 manual-based self-help interventions, acceptance and commitment therapy and applied relaxation, for persons with chronic pain. *The Clinical Journal of Pain, 27*(8), 716–723. https://doi.org/10.1097/AJP.0b013e318219a933

Toffolutti, V., & Suhrcke, M. (2014). Assessing the short term health impact of the Great Recession in the European Union: a cross-country panel analysis. *Preventive Medicine, 64*, 54–62. https://doi.org/10.1016/j.ypmed.2014.03.028

Tolonen, H., Helakorpi, S., Talala, K., Helasoja, V., Martelin, T., & Prättälä, R. (2006). 25-year trends and socio-demographic differences in response rates: Finnish adult health behaviour survey. *European Journal of Epidemiology, 21*(6), 409–415. https://doi.org/10.1007/s10654-006-9019-8

Treede, R. D., Rief, W., Barke, A., Aziz, Q., Bennett, M. I., Benoliel, R., … Wang, S. J. (2015). A classification of chronic pain for ICD-11. *Pain, 156*(6), 1003–1007. https://doi.org/10.1097/j.pain.0000000000000160

Truelove, E., Huggins, K. H., Mancl, L., & Dworkin, S. F. (2006). The efficacy of traditional, low-cost and nonsplint therapies for temporomandibular disorder: a randomized controlled trial. *Journal of The American Dental Association (1939), 137*(8), 1099–1169. https://doi.org/10.14219/jada.archive.2006.0348

Truelove, E., Pan, W., Look, J. O., Mancl, L. A., Ohrbach, R. K., Velly, A. M., … Shiffman, E. L. (2010). The Research Diagnostic Criteria for Temporomandibular Disorders. III: validity of Axis I diagnoses. *Journal of Orofacial Pain, 24*(1), 35–47.

Türp, J. C., Komine, F., & Hugger, A. (2004). Efficacy of stabilization splints for the management of patients with masticatory muscle pain: a qualitative systematic review. *Clinical Oral Investigations, 8*(4), 179–195. https://doi.org/10.1007/s00784-004-0265-4

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

Valiente López, M., van Selms, M. K., van der Zaag, J., Hamburger, H. L., & Lobbezoo, F. (2015). Do sleep hygiene measures and progressive muscle relaxation influence sleep bruxism? Report of a randomised controlled trial. *Journal of Oral Rehabilitation, 42*(4), 259–265. https://doi.org/10.1111/joor.12252

van Grootel, R. J., Buchner, R., Wismeijer, D., & van der Glas, H. W. (2017). Towards an optimal therapy strategy for myogenous TMD, physiotherapy compared with occlusal splint therapy in an RCT with therapy-and-patient-specific treatment durations. *BMC Musculoskeletal Disorders, 18*(1), 76. https://doi.org/10.1186/s12891-017-1404-9

van Selms, M. K., Lobbezoo, F., Visscher, C. M., & Naeije, M. (2008). Myofascial temporomandibular disorder pain, parafunctions and psychological stress. *Journal of Oral Rehabilitation, 35*(1), 45–52. https://doi.org/10.1111/j.1365-2842.2007.01795.x

van Selms, M. K., Lobbezoo, F., Wicks, D. J., Hamburger, H. L., & Naeije, M. (2004). Craniomandibular pain, oral parafunctions, and psychological stress in a longitudinal case study. *Journal of Oral Rehabilitation, 31*(8), 738–745. https://doi.org/10.1111/j.1365-2842.2004.01313.x

van Selms, M. K., Muzalev, K., Visscher, C. M., Koutris, M., Bulut, M., & Lobbezoo, F. (2017). Are Pain-Related Temporomandibular Disorders the Product of an Interaction Between Psychological Factors and Self-Reported Bruxism? *Journal of Oral & Facial Pain and Headache, 31*(4), 331–338. https://doi.org/10.11607/ofph.1909 van Selms, M., Kroon, J., Tuomilehto, H., Peltomaa, M., Savolainen, A., Manfredini, D., … Ahlberg, J. (2020). Self-reported sleep bruxism among Finnish symphony orchestra musicians: Associations with perceived sleep-related problems and psychological stress. *Cranio: The Journal of Craniomandibular Practice*, 1–8. Advance online publication. https://doi.org/10.1080/08869634.2020.1853310

Velly, A. M., Look, J. O., Schiffman, E., Lenton, P. A., Kang, W., Messner, R. P., … Fricton, J. R. (2010). The effect of fibromyalgia and widespread pain on the clinically significant temporomandibular muscle and joint pain disorders--a prospective 18-month cohort study. *The Journal of Pain, 11*(11), 1155–1164. https://doi.org/10.1016/j.jpain.2010.02.009

Verhoeff, M. C., Koutris, M., van Selms, M., Brandwijk, A. N., Heres, M. S., Berendse, H. … Lobbezoo, F. (2021). Is dopaminergic medication dose associated with self-reported bruxism in Parkinson's disease? A cross-sectional, questionnaire-based study. *Clinical Oral Investigations, 25*(5), 2545–2553. https://doi.org/10.1007/s00784-020-03566-0

Vincent, K., & Tracey, I. (2008). Hormones and their Interaction with the Pain Experience. *Reviews In Pain, 2*(2), 20–24. https://doi.org/10.1177/204946370800200206

Visscher, C. M., & Lobbezoo, F. (2015). TMD pain is partly heritable. A systematic review of family studies and genetic association studies. *Journal of Oral Rehabilitation, 42*(5), 386–399. https://doi.org/10.1111/joor.12263

Visscher, C. M., Ligthart, L., Schuller, A. A., Lobbezoo, F., de Jongh, A., van Houtem, C. M., & Boomsma, D. I. (2015). Comorbid disorders and sociodemographic variables in temporomandibular pain in the general Dutch population. *Journal of Oral & Facial Pain and Headache, 29*(1), 51–59. https://doi.org/10.11607/ofph.1324

Vojdani, M., Bahrani, F., & Ghadiri, P. (2012). The study of relationship between reported temporomandibular symptoms and clinical dysfunction index among university students in Shiraz. *Dental Research Journal, 9(*2), 221–225. https://doi.org/10.4103/1735-3327.95240

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

von Piekartz, H., & Hall, T. (2013). Orofacial manual therapy improves cervical movement impairment associated with headache and features of temporomandibular dysfunction: a randomized controlled trial. *Manual Therapy, 18*(4), 345–350. https://doi.org/10.1016/j.math.2012.12.005

Wahlund, K., List, T., & Larsson, B. (2003). Treatment of temporomandibular disorders among adolescents: a comparison between occlusal appliance, relaxation training, and brief information. *Acta Odontologica Scandinavica, 61*(4), 203–211. https://doi.org/10.1080/00016350310003891

Wänman, A., & Marklund, S. (2020). Treatment outcome of supervised exercise, home exercise and bite splint therapy, respectively, in patients with symptomatic disc displacement with reduction: A randomised clinical trial. *Journal of Oral Rehabilitation, 47*(2), 143–149. https://doi.org/10.1111/joor.12888

Wetselaar, P., Vermaire, E., Lobbezoo, F., & Schuller, A. A. (2019). The prevalence of awake bruxism and sleep bruxism in the Dutch adult population. *Journal of Oral Rehabilitation, 46*(7), 617–623. https://doi.org/10.1111/joor.12787

Wetselaar, P., Vermaire, E., Lobbezoo, F., & Schuller, A. A. (2021). The prevalence of awake bruxism and sleep bruxism in the Dutch adolescent population. *Journal of Oral Rehabilitation, 48*(2), 143–149. https://doi.org/10.1111/joor.13117

White, K. P., Speechley, M., Harth, M., & Ostbye, T. (1999). The London Fibromyalgia Epidemiology Study: direct health care costs of fibromyalgia syndrome in London, Canada. *The Journal of Rheumatology, 26*(4), 885–889.

Wicksell, R. K., Olsson, G. L., & Hayes, S. C. (2010). Psychological flexibility as a mediator of improvement in Acceptance and Commitment Therapy for patients with chronic pain following whiplash. *European Journal of Pain (London, England), 14*(10), 1059.e1–1059.e11. https://doi.org/10.1016/j.ejpain.2010.05.001

Wieckiewicz, M., Boening, K., Wiland, P., Shiau, Y. Y., & Paradowska-Stolarz, A. (2015). Reported concepts for the treatment modalities and pain management of temporomandibular disorders. *The Journal of Headache and Pain, 16*, 106. https://doi.org/10.1186/s10194-015-0586-5

Wieckiewicz, M., Grychowska, N., Wojciechowski, K., Pelc, A., Augustyniak, M., Sleboda, A., & Zietek, M. (2014). Prevalence and correlation between TMD based on RDC/TMD diagnoses, oral parafunctions and psychoemotional stress in Polish university students. *Biomed Research International, 2014*, 472346. https://doi.org/10.1155/2014/472346

Wieckiewicz, M., Zietek, M., Smardz, J., Zenczak-Wieckiewicz, D., & Grychowska, N. (2017). Mental Status as a Common Factor for Masticatory Muscle Pain: A Systematic Review. *Frontiers In Psychology, 8*, 646. https://doi.org/10.3389/fpsyg.2017.00646

Williams, A., Fisher, E., Hearn, L., & Eccleston, C. (2020). Psychological therapies for the management of chronic pain (excluding headache) in adults. *The Cochrane Database of Systematic Reviews, 8*(8), CD007407. https://doi.org/10.1002/14651858.CD007407.pub4

Willumsen, T., Vassend, O., & Hoffart, A. (2001). A comparison of cognitive therapy, applied relaxation, and nitrous oxide sedation in the treatment of dental fear. *Acta Odontologica Scandinavica, 59*(5), 290–296. https://doi.org/10.1080/000163501750541156

Winocur, E., Gavish, A., Finkelshtein, T., Halachmi, M., & Gazit, E. (2001). Oral habits among adolescent girls and their association with symptoms of temporomandibular disorders. *Journal of Oral Rehabilitation, 28*(7), 624–629. https://doi.org/10.1046/j.1365-2842.2001.00708.x

Winocur, E., Gavish, A., Voikovitch, M., Emodi-Perlman, A., & Eli, I. (2003). Drugs and bruxism: a critical review. *Journal of Orofacial Pain, 17*(2), 99–111.

Wolfe, F., Clauw, D. J., Fitzcharles, M., Goldenberg, D. L., Katz, R. S., Mease, P., … & Yunus, M. B. (2010). The American College of Rheumatology Preliminary Diagnostic Criteria for Fibromyalgia and Measurement of Symptom Severity. *Arthritis Care & Research,* 62(5), 600–610. https://doi.org/10.1002/acr.20140

Wolfe, F., Egloff, N., & Häuser, W. (2016). Widespread pain and low widespread pain index scores among fibromyalgia-positive cases assessed with the 2010/2011 fibromyalgia criteria. *Journal of Rheumatology,* 43(9), 1743–1748. https://doi.org/10.3899/jrheum.160153

Xie, C., Lin, M., Yang, H., & Ren, A. (2019). Prevalence of temporomandibular disorders and its clinical signs in Chinese students, 1979-2017: A systematic review and meta-analysis. *Oral Diseases, 25*(7), 1697–1706. https://doi.org/10.1111/odi.13016

Yalçın Yeler, D., Yılmaz, N., Koraltan, M., & Aydın, E. (2017). A survey on the potential relationships between TMD, possible sleep bruxism, unilateral chewing, and occlusal factors in Turkish university students. *Cranio: The Journal of Craniomandibular Practice, 35*(5), 308–314. https://doi.org/10.1080/08869634.2016.1239851

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

Zhang, S. H., He, K. X., Lin, C. J., Liu, X. D., Wu, L., Chen, J., & Rausch-Fan, X. (2020). Efficacy of occlusal splints in the treatment of temporomandibular disorders: a systematic review of randomized controlled trials. *Acta Odontologica Scandinavica, 78*(8), 580–589. https://doi.org/10.1080/00016357.2020.1759818

Original publications

I 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

II Huhtela, O. S., Näpänkangas, R., Karppinen, J., Kunttu, K., & Sipilä, K. (2021). Association of psychological distress and widespread pain with symptoms of temporomandibular disorders and self-reported bruxism in students. *Clinical and Experimental Dental Research.* 20 July 2021.https://doi.org/10.1002/cre2.472

III Huhtela, O. S., Koivisto, N., Hägg, V., & Sipilä, K. (2020). Effectiveness of applied relaxation method vs splint in treatment of temporomandibular disorders in Finnish students. *Journal of Oral Rehabilitation, 47*(2), 123–131. https://doi.org/10.1111/joor.12884

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