PREVALENCE OF TEMPOROMANDIBULAR DYSFUNCTION IN PEOPLE EXPERIENCING HEADACHE AND ITS RECIPROCAL RELATIONSHIP: A SYSTEMATIC REVIEW AND META-ANALYSIS

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Declaration

I declare that this research report is my own, unaided work. It is being submitted for the Degree of Master of Physiotherapy at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

(Signature of candidate)

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Abstract

Background

Temporomandibular dysfunction (TMD) is a disorder of the temporomandibular joint and associated orofacial structures. It is the second most common musculoskeletal disorder experienced by adults. Headache is one of the most pervasive neurological disorders and can be an extremely disabling condition. TMD and headache are known to frequently occur simultaneously and have a bi-directional relationship. Due to their close anatomical association TMD has been shown to generate headaches and headaches have been shown to cause TMD. The aim of this systematic review was to determine the prevalence of TMD occurring concurrently in people experiencing headache as well as the prevalence of headache occurring concurrently in people experiencing TMD.

Method

An extensive search of all databases was conducted using the keywords 'temporomandibular dysfunction', 'TMD', 'TMJ', 'headache', 'migraine', 'migraine without aura', tension-type headache' and 'cervicogenic headache'. Only studies conducted on adults were included. The Joanna Briggs Institute Critical Appraisal Checklist for Studies Reporting Prevalence Data was used to assess methodological quality of the included studies. Fourteen studies were included for meta-analysis and two studies could not be included in the meta-analysis and were described narratively. The results of all the studies were pooled using MedCalc statistical software. The prevalence of TMD within people experiencing headache was measured as well as within various headache sub-groups namely migraine, migraine without aura, tension-type headache, concurrent migraine and tension-type headache, cervicogenic headache and chronic headache. The prevalence of headache and various headache sub-groups within people experiencing TMD was measured as well. Male and female prevalence of TMD and headache in the various sub-groups was measured too. Due to the variance and differences in study types and number of participants, the random effects model was used for data-analysis to accommodate the expected high heterogeneity for some of the prevalence results.

Results

The total prevalence of TMD in people experiencing headache was 60.72%. The prevalence of TMD in the various headache sub-groups was as follows: 63.36% in people with migraine; 55.56% in people with migraine without aura; 75% in people with concurrent migraine and tension-type headache; 49.26% in people with tension-type headache; 44.67% in people with cervicogenic headache and 70.85% in people with chronic headache. The total prevalence of TMD in females with headache was 49.79% and in males with headache was 11.86%. The total prevalence of headache in people with TMD was 63.90%. The prevalence of the various headache sub-groups in people with TMD were as follows: 45.15% of people had migraine, 69% of people had concurrent migraine and tension-type headache, 28.58% of people had tension-type headache and 7.12% of people had chronic headache. The total prevalence of headache in females with TMD was 47.52% and 14.75% in males.

Conclusion

TMD was found to be highly prevalent in people experiencing headache, and had the highest prevalence in people with concurrent migraine and tension-type headache. Headache was found to be a prevalent comorbidity in people experiencing TMD, and the most prevalent headache type seen in individuals experiencing TMD was also concurrent migraine and tension-type headache. When treating people with headache it seems pertinent to correctly diagnose the headache type and determine if TMD is present. If headache is present in people diagnosed with TMD, it is imperative to determine if the headache is caused by TMD or is in fact a primary headache such as migraine or tension-type headache. If TMD is present in people experiencing headache, it would be prudent to treat the orofacial structures to maximise the efficacy of headache treatment. Future studies on the prevalence of TMD within people experiencing migraine without aura and cervicogenic headache would be beneficial as there have been limited studies on these headache groups to date.

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List of abbreviations

AAOP: American Academy of Orofacial Pain

CINAHL: Cumulative Index to Nursing and Allied Health Literature

DC/TMD: Diagnostic Criteria for TMD

ICHD: International Classification of Headache Disorders

IHS: International Headache Society

JBI-MAStARI: Joanna Briggs Institute Meta-Analysis of Statistics Assessment and Review Instruments

PEDro: Physiotherapy Evidence Database

TMJ: Temporomandibular joint

TMD: Temporomandibular dysfunction

TTH: Tension-type headache

RDC/TMD: Research Design Criteria for TMD

YLD: Years lived with disability

Chapter 1: Introduction and scope of research report

1.1 Introduction

Temporomandibular dysfunction (TMD) is a disorder of the temporomandibular joint (TMJ) and associated structures, including the TMJ disc-condyle relationship, muscles of mastication and headache attributed to TMD (Graff-Radford, 2007; Hara et al., 2016; Kraus, 2007). Second to chronic low back pain, TMD is the next most frequent musculoskeletal disorder and is said to occur in 51% of people during their lifetime (Speciali and Dach, 2015; Steiner et al., 2016).

In adults under 50 years old, Headache is one of the most prevailing neurological disorders (Steiner et al., 2016). According to the Global Burden of Disease, all types of headache are third on the list of disability in people under 50 years old and migraine is ranked as the sixth most disabling condition (Steiner et al., 2016).

Migraine is a disabling primary headache with idiopathic aetiology and a very high prevalence (Jensen et al., 1993; Jensen and Stovner, 2008; Steiner et al., 2016). The two common subtypes of migraine are migraine without aura and migraine with aura, with most people experiencing migraine without aura (Jensen and Stovner, 2008; Steiner et al., 2016). Migraine occurs more often in women than in men, especially women of reproductive age (Franco et al., 2010; Gonçalves et al., 2013; Jensen and Stovner, 2008).

The other primary headache of interest in this study is tension-type headache. Although tension-type headache is less disabling than migraine, it has a higher global prevalence (Jensen and Stovner, 2008; Steiner et al., 2016). Its high prevalence is because tension-type headache is often considered a 'normal headache' and is considered one of the five most prevalent conditions which cause disability in women (Jensen and Stovner, 2008).

A secondary headache is a headache attributed to another underlying disease or condition (Chou and Lenrow, 2002; IHS, 2013; Olesen, 2005). Of the secondary headaches that occur, cervicogenic headache is the only headache type of interest in this review. Cervicogenic headache was first named by Sjaastad in 1983 (Chou and Lenrow, 2002). Prior to this it was a difficult condition to define and its origin of pain was unclear and debated. There are still many hypotheses of the mechanism of action of cervicogenic headache, but it is now agreed on that the neuroanatomical structures of the cervical spine are a large causative agent in cervicogenic headache pain (Chou and Lenrow, 2002; Rana, 2013).

There is much evidence from the literature that TMD and headache have a reciprocal relationship and frequently occur together (Kraus, 2007; Speciali and Dach, 2015; Troeltzsch et al., 2011). Since the head, neck, jaw and masticatory muscles all have common neural innervation and closely related anatomical structures, they are intrinsically connected in their ability to generate symptoms within the surrounding structures (Chou and Lenrow, 2002; Gonçalves et al., 2013; Graff-Radford, 2007; Kraus, 2014; Rana, 2013; Silva Jr et al., 2014; Speciali and Dach, 2015).

Since it has been shown that headaches have an integral relationship with TMD (Ciancaglini and Radaelli, 2001; Graff-Radford, 2007; Kraus, 2007; Speciali and Dach, 2015; Troeltzsch et al., 2011), the pooled prevalence of this relationship should be documented by reviewing the literature available. The significance of ascertaining the prevalence will influence the treatment and management of these headache types. If there is found to be a high prevalence, this would then mean that it may be prudent for physiotherapists to include orofacial care in in the management of patients presenting with these headache types. Orofacial refers to orthopaedic manipulative therapy treatment of the jaw and facial musculature in this text. Orofacial care has been shown to relieve headache pain in people experiencing headaches and TMD, as well as significantly improve the headache intensity and duration as well cervical spine range of motion and pain (Graff-Radford and Newman, 2002; Kraus, 2007; von Piekartz and Hall, 2013). By adding orofacial care to headache treatments, physiotherapists could potentially significantly reduce the frequency and intensity of the headache as well as reduce TMD pain and improve functioning of the orofacial structures (Bernstein et al., 2013; Graff-Radford and Bassiur, 2014; Kraus, 2007; Stuhr et al., 2014).

Both TMD and headache are prevalent conditions, and studies have been done to see if headache cause TMD or if TMD creates headache (Caspersen et al., 2013; Ciancaglini and Radaelli, 2001; Hara et al., 2016; Speciali and Dach, 2015). Although most of these studies investigated the causal relationship between TMD and headache, there are no systematic reviews focusing just on the prevalence of TMD and headache, and their bidirectional relationship, within the adult population only.

1.2 Problem statement

Headaches are a well-researched and studied topic. There is an abundance of studies focusing on tension-type headaches, cervicogenic headaches, and migraine without aura (Benoliel and Eliav, 2013; Bernstein et al., 2013; Caspersen et al., 2013; Chou and Lenrow, 2002; Freitag, 2013; Freitag, 2006; Graff-Radford, 2006; Rana, 2013). Their classification, symptoms, causes and treatment are well documented. Temporomandibular disorders are also well studied and described in current literature. Many studies have examined the classification of TMD and a distinction can be made between arthrogenous TMD (pertaining to the joint and disc) and myogenous TMD, (pertaining to masticatory and orofacial musculature) (Ferreira et al., 2016; Fricton, 2007; Kraus, 2007). Headaches, particularly tension-type headaches, seem to occur more frequently with myogenous TMD and TMD is a co-morbid factor in headache generation (Caspersen et al., 2013; Goncalves et al., 2010; Graff-Radford, 2007). From the available literature, there is a definitive association between headaches and TMD, and their relationship has been shown to be bidirectional (Bernstein et al., 2013; Speciali and Dach, 2015; Troeltzsch et al., 2011). Headaches are commonly misdiagnosed as a primary headache, when the generator is often the jaw (Kraus 2007). There are many studies investigating the relationship between headaches and TMD but no systematic reviews have been performed to establish the pooled prevalence of TMD in adults with headache and the prevalence of headache occurring in adults with TMD as one study.

1.3.1 Systematic review questions

The answers to two pertinent research questions will be explored in this systematic review:

- What is the prevalence of TMD in individuals experiencing headaches?
- What is the prevalence of headache in people experiencing TMD?

1.3.2 Systematic review objectives

The objectives of this systematic review were to:

- establish the prevalence of TMD in individuals experiencing headache
- establish the prevalence of headache in individuals experiencing TMD

1.4 Significance of the study

Since it has been shown that headaches have an integral relationship with TMD, the pooled prevalence of this relationship should be documented by reviewing the available literature. Ascertaining the prevalence of TMD may influence the treatment and management of these headache types. If there is a significant prevalence of TMD within the headache population, this study will also highlight the importance of correctly diagnosing TMD in line with the Research Diagnostic Criteria for TMD (RDC/TMD) (Schiffman et al., 2014) and headache type as per the International Classification of Headache Disorders (ICHD-II)(IHS, 2013). By ascertaining how frequently these conditions occur together, better management of these comorbid conditions can be advocated for. Since TMD and headaches appear to have an entwined relationship, it can be difficult to distinguish whether the headache exists on its own, or is caused by TMD. If concurrent headache and TMD are shown to be highly prevalent in this review, correct identification and diagnosis of headache and TMD will possibly lead to better treatment considerations and subsequent outcomes for people with headache and TMD.

Chapter 2: Literature review

2.1 Introduction

Every person will experience at least one headache type at some point in their life. The Global Burden of Disease Study is a yearly study conducted to determine global prevalence of disease and injury across 21 regions. In 2013 tension-type headache was reported to affect 1.6 billion people globally and is responsible for a large amount of work-place absenteeism (Bernstein et al., 2013). In order to quantify or classify disability, it is measured in 'years lived with disability (YLD)'. Migraine ranked sixth in developed countries and seventh in developing countries, on this disability scale (IHS, 2013; Olesen, 2005; Steiner et al., 2016). Migraine is estimated to be the most incapacitating headache disorder, even though tension-type headache is the second most prevalent headache type and more prevalent than migraine (Steiner et al., 2016). Cervicogenic headaches are responsible for 15-20% of chronic headaches in the headache population (Bernstein et al., 2013).

TMD is the second most common musculoskeletal disorder among adults and is responsible for significant pain and disability in people with the disorder. It is said to cost $4 billion in the USA for the treatment and management of TMD (Schiffman et al., 2014) and is a large cause of work-place absenteeism (Rantala et al., 2003).

To understand the disability and morbidity caused by headache and TMD, this review will describe migraine, tension-type and cervicogenic headache types and their pathophysiology and prevalence to understand their global affect. TMD will be discussed, as well as its pathophysiology and its integral relationship with headache, and its role as a comorbidity within the headache population. This review aims to show the prevalent relationship between TMD and headache.

2.2. Search strategy of literature review

An initial search of Pubmed and CINAHL was executed. Preliminary key words used included headache, cervicogenic headache, tension-type headache, migraine, migraine without aura, orofacial pain, orofacial care, temporomandibular disorder, temporomandibular joint, and myogenous TMD. The titles, abstracts and index terms were analysed after which a

comprehensive search of the following databases was done: MEDLINE via PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), the Cochrane Controlled Trials Register in the Cochrane Library, Physiotherapy Evidence Database (PEDro), ProQuest 5000 International, ProQuest Health and Medical Complete, EBSCO MegaFile Premier, Science Direct and SCOPUS. The reference lists of all the selected full text articles were examined for additional studies to include. Studies published from inception until 31 January 2017 were considered in the search process.

2.3. TMD

TMD is characterised by various pathologies affecting the temporomandibular joint, muscles of mastication and affiliated structures of the jaw and is the second-most common musculoskeletal disorder causing pain and disability (Ferreira et al., 2016; Kraus, 2014; Rantala et al., 2003; Schiffman et al., 2014; Speciali and Dach, 2015). TMD often presents with pain in the temporomandibular joint, pain in the masticatory muscles, pain with and restriction of mouth opening and chewing, as well as joint noises and crepitus (Ferreira et al., 2016; Graff-Radford, 2007; Kraus, 2014; Manfredini et al., 2006; Speciali and Dach, 2015). Pain is the predominant symptom of TMD but it is also possible to have pain-less symptoms associated with TMD such as limited jaw opening ability, decreased jaw mobility, crepitus and headache (Rantala et al., 2003).

TMD is an extremely common disorder in the adult population and the second most common musculoskeletal disorder in adults (Schiffman et al., 2014). It has a varied prevalence ranging from 3-54.3% in all adults and occurs more commonly in women than in men (Ballegaard et al., 2008; Ciancaglini and Radaelli, 2001; Ferreira et al., 2016; Fricton, 2007; Graff-Radford, 2007; Graff-Radford and Abbott, 2016; Kraus, 2007; Kraus, 2014; Rantala et al., 2003; Schiffman et al., 2014; Speciali and Dach, 2015).

Epidemiological studies have shown the prevalence of TMD in women to range from 15-26% and in men from 8-15.4% (Ballegaard et al., 2008; Ciancaglini and Radaelli, 2001). TMD occurs most often between 20 and 50 years of age and often peaks in the fourth decade (Ciancaglini and Radaelli, 2001; Ferreira et al., 2016; Fricton, 2007; Graff-Radford, 2007; Kraus, 2014; Speciali and Dach, 2015).

2.3.1 Aetiology of TMD

Inflammation within the temporomandibular joint (TMJ) is greatly responsible for pain felt within the joint. Synovitis and capsulitis, usually post-traumatic are large causes of inflammation in the joint. Sprains of capsular ligaments around the TMJ can also cause inflammation in and around the joint. Usually the pain is reported as dull but can be sharp with mouth opening and closing (Graff-Radford, 2007).

Dysfunction within the TMJ is due to disc-condyle incoordination. This is usually due to ligamental injury of the TMJ or mandibular-condyle displacement. This is often responsible for the clicking sound and difficulty with jaw movements (Ferreira et al., 2016; Graff-Radford, 2007; Graff-Radford and Bassiur, 2014).

Of pain disorders that occur, myofascial pain is the most prevalent and is present in 20-50% of adults (Fricton, 2007) and is characterised by an area of localised muscle pain and is associated with active or latent trigger points in muscle, fascia or tendons (Graff-Radford, 2007; Graff-Radford and Bassiur, 2014).

2.3.2 Classification of TMD

TMD can be classified as either intra-articular or extra-articular, with the latter primarily being myogenous TMD. Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) is a classification system for temporomandibular joint disorders (Manfredini et al., 2006; Schiffman et al., 2014). As per the DC/TMD, TMD is classified into the following groups: arthrogenous TMD (including joint and disc disorders), masticatory muscle disorders (myogenous TMD) and headache (attributed to TMD) (Schiffman et al., 2014).

a) Arthrogenous TMD

Arthrogenous TMD has a prevalence of 57% in adults with TMD (Kraus, 2014). There are two common disc disorders associated with TMD, namely disc displacement with reduction, and disc displacement without reduction (Graff-Radford, 2007; Schiffman et al., 2014). Disc displacement with reduction occurs when a momentary misaligned disc realigns with the mandibular condyle during mouth opening and produces a characteristic click sound (Graff-Radford, 2007; Manfredini et al., 2006). Disc displacement without reduction is the result of a disc that does not correct its tracking/position in relation to the condyle with jaw movement

(Graff-Radford, 2007; Manfredini et al., 2006). Clicking of the TMJ ceases with the sudden onset of pain in the TMJ and there is restricted opening of the mouth (Graff-Radford, 2007). Disc displacement of the TMJ may not always be pathological but can progress over many years to contribute to TMD (Graff-Radford, 2007; Manfredini et al., 2006). Chronic disc displacement without reduction can lead to osteoarthritic changes in the TMJ over time (Graff-Radford, 2007). Symptoms of disc displacement without reduction are usually pain with mouth opening, deflection of the jaw to the side of the affected disc during mouth opening, limited laterotrusion to the unaffected side and lack of joint noise with opening and closing (Graff-Radford, 2007; Manfredini et al., 2006; Schiffman et al., 2012; Schiffman et al., 2014).

b) Myogenous TMD

Myogenous TMD (also referred to as masticatory myalgia) is a disorder of the jaw musculature characterised by myofascial pain in the masticatory muscles (Fricton, 2007). It has a prevalence of 20-50% in adults with TMD and occurs more commonly in women than in men (Ferreira et al., 2016; Fricton, 2007; Manfredini et al., 2006). It is the most frequent origin of persistent muscular pain in the face and head and is the most frequent cause of TMD (Ferreira et al., 2016). Myofascial pain is one of the most frequently occurring muscle disorders and masticatory myofascial pain presents as jaw pain and facial pain and is well known to refer temple, frontal and occipital headaches (Freitag, 2013; Graff-Radford, 2007). People with myogenous TMD are more likely to experience headaches than those with arthrogenous TMD, with migraine and tension-type headache being the most prevalent (Ferreira et al., 2016; Fricton, 2007; Graff-Radford, 2007; Graff-Radford and Bassiur, 2014; Kraus, 2007).

2.4 Headache

Headache can be an extremely disabling condition that affects almost every person at some point in their life. The lifetime prevalence of experiencing any type of headache is high, with 69% of men and 88% of women complaining of headache at some point in time (Jensen and Stovner, 2008; Troeltzsch et al., 2011). The global prevalence of reported headache in adults is 47% (Jensen and Stovner, 2008).

Headache is diagnosed based on criteria set out according to The International Classification of Headache Disorders (IHS) (IHS, 2013). For the purpose of this review, only primary and

secondary headache types will be focussed on. Primary headaches of interest in this review include migraine and tension-type headache and secondary headache type of interest is cervicogenic headache. Headache without anatomical or physiological explanation and unknown pathology are considered primary headaches (Benoliel and Eliav, 2013; Bernstein et al., 2013). Secondary headaches are classified as headache caused by another disease or pathology such as cervicogenic headache or TMD-related headache (Bernstein et al., 2013; Chou and Lenrow, 2002; Hara et al., 2016; Rana, 2013).

2.4.1 Primary headache

a) Migraine

Migraine is a debilitating neurological condition and has a significantly disabling effect on quality of life in people with frequent episodes of migraine (Lancet, 2015; Steiner et al., 2016). There are two types of migraine, namely migraine with aura and migraine without aura. Migraine without aura is the most prevailing form of migraine headache and is an inherited condition with an onset before 20 years of age in 50% of people with this condition (Benoliel and Eliav, 2013; Bernstein et al., 2013).

Migraine typically presents with a unilateral headache, has a throbbing or pulsatile quality to it, has a moderate to severe intensity which can halt normal daily activities, and is aggravated by walking or usual physical activity (Benoliel and Eliav, 2013; IHS, 2013). During the migraine period, nausea and/or vomiting occurs as well as phonophobia and/or photophobia (Benoliel and Eliav, 2013; IHS, 2013). Migraine headache phase usually last 4-72 hours (Benoliel and Eliav, 2013; Bernstein et al., 2013; Jensen et al., 1993; Tomaz-Morais et al., 2015). The occurrence of aura differentiates between migraine without aura and migraine with aura (Bernstein et al., 2013). The aura usually includes visual, motor or sensory disturbances and lasts less than 60 minutes (Bernstein et al., 2013). Migraine without aura is the most predominant type of migraine experienced by adults. (Benoliel and Eliav, 2013). Eighty five percent of people living with migraine do not present with aura and up to 30% experience aura (Bernstein et al., 2013).

Migraine has been documented as the third most prevalent disorder (IHS, 2013) and has a global prevalence of 10-12% and lifetime prevalence of 14% (Benoliel and Eliav, 2013; Jensen

and Stovner, 2008). The usual age of onset is between 20 and 30 years old and culminates in the fourth decade and then usually declines in frequency (Benoliel and Eliav, 2013; Bernstein et al., 2013; Jensen and Stovner, 2008). Women have been shown to experience migraine more often than men (18% and 6% respectively) (Bernstein et al., 2013), with a male to female ratio of 1:3 (Jensen and Stovner, 2008). Of people experiencing migraine, 94% have concurrent tension-type headache and migraine has been seen to trigger the onset of tension-type headache in some people (Ballegaard et al., 2008; Jensen and Stovner, 2008).

b) Tension-type headache

Tension-type headache is characterised by frequent bouts of pain, usually occurring bilaterally, with a compressive or constricting quality to it and is mild to moderate in intensity (Freitag, 2013; IHS, 2013). The headache can last minutes to days. The pain is not exacerbated with ordinary physical activity and is not accompanied by nausea and/or vomiting, but photophobia or phonophobia may be present in some cases (Benoliel and Eliav, 2013; IHS, 2013). Tension-type headache is the most common type of headache in adults (Benoliel et al., 2008; Benoliel and Eliav, 2013; Bernstein et al., 2013; Freitag, 2013; Freitag, 2006; Graff-Radford, 2007; Jensen and Stovner, 2008; Tomaz-Morais et al., 2015). Tension-type headache can be described as episodic or chronic, with episodic tension-type headache further classified as frequent or infrequent (Benoliel and Eliav, 2013) (IHS, 2013). Infrequent episodic tension-type headache is defined as tension-type headache which occurs less than once per month and frequent episodic tension-type headache occurs more than 1 day per month but less than 15 days per month (Benoliel and Eliav, 2013). Episodic tension-type headache is the most common headache globally with a 30% prevalence and tension-type headache in total has 38% prevalence worldwide (Bernstein et al., 2013; Freitag, 2006; Jensen and Stovner, 2008; Tomaz-Morais et al., 2015).

Tension-type headache occurs most often at the ages between 20 and 39 years old with an average onset between 25 to 30 years of age (Benoliel and Eliav, 2013; Freitag, 2013). It has a peak prevalence between 30 and 50 years of age and then declines with aging (Benoliel and Eliav, 2013; Freitag, 2013). Females are more affected by tension-type headache than males with a ratio of 4:5 respectively (Jensen and Stovner, 2008). Compared to migraine, women are

marginally more affected by tension-type headache than men (Benoliel and Eliav, 2013; Freitag, 2006; Jensen and Stovner, 2008; Tomaz-Morais et al., 2015).

Tension-type headache can become chronic over time, with people experiencing a tension-type headache on more than 15 days of the month (Bernstein et al., 2013). Chronic tension-type headache can be difficult to distinguish apart from migraine as they can also present with nausea (Bernstein et al., 2013; Jensen and Stovner, 2008). Epidemiological studies have shown that the global burden of tension-type headache is highest in Central and South America and Europe, with the lowest rates being in Africa (Jensen and Stovner, 2008). This however could be under-represented due to fewer studies being conducted on tension-type headache in Africa.

The exact pathophysiology of tension-type headache is still speculated, but commonly there seems to be pericranial muscle tenderness, trigger points and muscular pathology involved in triggering tension-type headache (Bernstein et al., 2013). It has been suggested that prolonged nociceptive stimulation of the pericranial myofascial structures leads to sensitisation of pain pathways, dysfunction of descending inhibitory pathways, leading to pericranial muscle spasm, and ultimately causing tension-type headaches to become chronic (Benoliel and Eliav, 2013; Bernstein et al., 2013; Freitag, 2006). It has been estimated that 16% of people with episodic tension-type headache develop chronic tension-type headache in time (Freitag, 2006). Differential diagnosis of tension-type headache relies on careful history taking as they mimic migraine very closely, bar the presence of nausea and vomiting usually (Bernstein et al., 2013).

Tension-type headache was previously classified as tension headache; muscle contraction headache; stress headache; idiopathic headache or psychogenic headache (IHS, 2013; Olesen, 2005). This highlights the psychosocial aspect that underlies this headache type. People with tension-type headache, especially chronic headache, usually have some symptoms of depression and anxiety (Freitag, 2006). Patients with depression tend to wake up with more pain and headache, yet not awoken from their sleep due to headache pain. Those with high levels of anxiety and stress tend to experience worsening headache symptoms as they day progresses (Freitag, 2006).

2.4.2 Secondary headache

The IHS classifies secondary headaches as a headache which occurs concurrently with another condition by chance and without a definitive causal agent (IHS, 2013; Olesen, 2005). Secondary headaches usually occur as a result of another disease or underlying condition (Bernstein et al., 2013). These disorders can include cervicogenic headaches and headaches attributed to TMD.

a) Cervicogenic headache

The term 'cervicogenic headache' was originally named by Sjaastad et al in 1983, prior to which they were idiopathic headaches coined as occipital neuralgias (Chou and Lenrow, 2002). Cervicogenic headache is a headache affiliated to the structures of the cervical spine including the vertebrae, discs and soft tissue structures surrounding the joints (Bernstein et al., 2013; IHS, 2013). This headache type is primarily associated with myofascial pain disorder stemming from the neck (Kraus, 2007) (Chou and Lenrow, 2002; Rana, 2013). They are characterised by pericranial muscle tenderness and can be infrequent episodic headaches or frequent episodic headaches (Bernstein et al., 2013; IHS, 2013). Although it has been hypothesised that upper cervical spine nerves and structures of the cervical spine are the cause of this headache type, there is no differential test to prove the cause of cervicogenic headache (Rana, 2013). Diagnosis is therefore based upon patterns of the headache and ruling out other headache types (Rana, 2013).

People with cervicogenic headache typically present with headache that timeously coincides with the onset of cervical spine pain and dysfunction (Bernstein et al., 2013; IHS, 2013; Kraus, 2007). The headache usually presents unilaterally in the sub-occipital/occipital area and refers pain to the temporal and periorbital areas of the head/face (Bernstein et al., 2013; Chou and Lenrow, 2002; Rana, 2013). In 16% of people with occipital pain, the atlantoaxial joint is implicated in the cause of the headache (Rana, 2013). The pain is usually moderate and non-pulsatile, intermittently or continuously. There is simultaneous pain in the cervical spine with a loss in range of motion and the headache is induced with cervical spine movement, particularly, cervical spine extension (Bernstein et al., 2013; Rana, 2013). Other symptoms that can manifest with cervicogenic headache are dizziness and blurred vision (Chou and Lenrow, 2002).

Prevalence of cervicogenic headache in adults has been reported as 0.4 - 4% (Bernstein et al., 2013; Chou and Lenrow, 2002). It is estimated that 15 – 35.4% of people may have chronic cervicogenic headache (Bernstein et al., 2013; Chou and Lenrow, 2002; Rana, 2013). It is more prevalent in females than in males with a ratio of 4:1 respectively with the average age being 40 years old (Bernstein et al., 2013; Rana, 2013). People can have more than one headache type concurrently or be can be misdiagnosed with migraine and tension-type headache instead of cervicogenic headache (Rana, 2013). Due to the cervical spine pathogenesis in cervicogenic headaches, cervicogenic headaches can be elicited by neck movements (Chou and Lenrow, 2002). Cervicogenic headaches can be distinguished from migraine and tension-type headaches by their persistent origin from the neck and occipital/nuchal area of the head as well as the absence of phono/photophobia and nausea (Chou and Lenrow, 2002).

2.5 TMD and headache

From the literature, it is evident that both TMD and headache are prevalent conditions affecting a large amount of the adult population. (Benoliel and Eliav, 2013; Bernstein et al., 2013; Ferreira et al., 2016; Fricton, 2007; Graff-Radford, 2007; Hara et al., 2016; Kraus, 2007; Rantala et al., 2003; Speciali and Dach, 2015; Tomaz-Morais et al., 2015; Troeltzsch et al., 2011). One of the most frequent symptoms and complaints of TMD sufferers, particularly myogenous TMD, are headaches (Kraus, 2014). Headaches and TMD are so common that they could either be affiliated or separate entities (Speciali and Dach, 2015). As such, TMJ and other orofacial structures such as masticatory muscles should be considered when ascertaining the cause of the headache (Ferreira et al., 2016; Fricton, 2007; Graff-Radford, 2007; Kraus, 2014; Rantala et al., 2003; Speciali and Dach, 2015).

There is a clear reciprocal relationship between TMD and headache. TMD has been implicated in the generation of headache with migraine being the most common headache type diagnosed in people with TMD who are exhibiting headache symptoms (Ballegaard et al., 2008; Franco et al., 2010; Gonçalves et al., 2010; Gonçalves et al., 2013; Gonçalves et al., 2013). People who have TMD are more likely to experience headache and headache occurs more often in people with TMD than those without (Ciancaglini and Radaelli, 2001; Gonçalves et al., 2010; Gonçalves et al., 2013). The relationship between TMD and headache is bi-directional and each increases the prevalence of the other condition (Speciali and Dach, 2015).

TMD is most commonly seen in people experiencing migraines and those with tension-type headache, most noticeably when people have both migraine and tension-type headache together (Ballegaard et al., 2008; Di Paolo et al., 2009). TMD is a prominent comorbidity of those with chronic headache and seen the least in people who have only tension-type headache (Ballegaard et al., 2008; Gonçalves et al., 2010; Melo et al., 2012).

Myogenous TMD was found to be a large risk factor for headache, more commonly than arthrogenous TMD (Glaros et al., 2014; Graff-Radford, 2007). Headache patients diagnosed with TMD were much more likely to have myogenous TMD (Anderson et al., 2011; Troeltzsch et al., 2011). The highest amount of reported headache symptoms occur in people with muscular pathology of the jaw and temporomandibular joint, with the most frequency occurring in females aged 30-60 years (Goncalves et al., 2010; Gonçalves et al., 2013; Speciali and Dach, 2015; Troeltzsch et al., 2011).

The lack of descending neural inhibition, neural overlap of the trigeminal nerve to the head and jaw, and the upper cervical spine pain referral from upper cervical spinal nerves all play a role in simultaneous headache and jaw pain (Freitag, 2006; Graff-Radford, 2007; Troeltzsch et al., 2011). Due to the neural overlap between the jaw musculature, head/face musculature and temporomandibular joint, the temporal muscles are commonly found to be hyperactive with higher tension than normal. Due to the increased muscle contraction, bruxism and jaw clenching often occur (Caspersen et al., 2013). This often triggers headache and temporomandibular pain, even in cases without prior TMD (Freitag, 2013). It is therefore pertinent to get a global prevalence of TMD being present in individuals experiencing headache and how frequently TMD causes headache.

2.6 Conclusion

Headaches and TMD are both common disorders. Both these conditions afflict much of the population, with women more commonly affected than men. There is a large interrelationship between headache and TMD sufferers and its often difficult to separate the cause of headache when headache sufferers have a concurrent temporomandibular disorder. The literature also shows that headache sufferers are more likely to have TMD symptoms than those without

headaches. TMD alone can generate and be the source of headaches, particularly, tension-type headache, migraine and cervicogenic headache. Due to the close anatomic and neural links between the jaw and neck, their interrelationship is pivotal in headache generation and vice versa. The pertinence of a prevalence study on TMD occurring simultaneously with headaches will indicate the need to correctly diagnose the cause of headache. If TMD is shown to be highly prevalent in people experiencing headaches, correctly identifying TMD within the headache population may show the relevance of applying an appropriate combination of treatment of both headache and the orofacial structures.

Chapter 3: Methodology

This systematic review followed the Joanna Briggs Institute (JBI) Systematic Review methodology outlined in the Joanna Briggs Institute Reviewers' Manual (Joanna Briggs Institute 2014) and the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA GROUP) guidelines (Liberati et al., 2009).

3.1 Type of study

This study was a systematic review with meta-analysis.

3.2 Inclusion criteria

3.2.1 Types of participants

This systematic review included all studies done on participants complaining of headaches (migraine, migraine without aura, tension-type and cervicogenic headache) and symptoms of TMD concurrently. The studies included adult participants who were 18 years and older. Studies using both male and female participants were included. Studies done where participants had a periodontal cause of orofacial pain such as gum disease, tooth abscess or any oral cavity disease were excluded from the review so as to eliminate any other cause of orofacial pain other than TMD.

3.2.2 Phenomena of interest

Headaches, cervicogenic headaches, tension-type headaches and migraine without aura and chronic headaches were the only headache types included in the review. Any other headache type was excluded from the review. TMD included both arthrogenous and myogenous TMD within the studies. Studies from all countries and healthcare settings were considered in this review to get a global prevalence.

3.2.3 Types of outcomes

Studies looking at prevalence of simultaneous headache and TMD amongst adult individuals were included in this review. In addition to prevalence, male to female prevalence and age of the sample group in the studies, were areas of interest. Only studies measuring prevalence of

concurrent headache and TMD or where prevalence could be measured from the results, were included.

3.2.4 Types of sources

Experimental and epidemiological study designs including randomised controlled trials, non-randomised controlled trials, prospective and retrospective cohort studies, before and after studies, case control studies and analytical cross-sectional studies were considered for inclusion in this systematic review. This systematic review also looked at descriptive epidemiological study designs including descriptive cross-sectional studies. Only peer-reviewed studies were included. Full-text studies written in all languages were considered. All articles included in this study were written in English and did not need to be translated.

3.3 Search strategy

The search strategy examined published studies written in all languages, since inception until 31 January 2017. The search strategy involved a series of steps. An initial search of Pubmed was executed, followed by Cumulative Index to Nursing and Allied Health Literature (CINAHL), the Cochrane Controlled Trials Register in the Cochrane Library, EBSCO MegaFile Premier, Physiotherapy Evidence Database (PEDro), ProQuest Health and Medical Complete, Science Direct and SCOPUS. Preliminary key words included: headache, cervicogenic headache, tension-type headache, migraine, migraine without aura, orofacial pain, orofacial care, temporomandibular disorder, temporomandibular joint, and myogenous TMD. This was followed by scanning of the words contained in the title and abstract, and of the index terms used to characterise the article. A second search using all recognised keywords and index terms was then carried out across all databases mentioned below. After this, the reference lists of all relevant and selected reports and articles were searched for additional studies. The initial and second searches were conducted by the primary researcher and full text articles were included when inclusion criteria were met after reviewing titles and abstracts of studies. The keywords used in the search builder are shown in Table 3.1 below.

Table 3.1 Keywords used in search strategy

Temporomandibular-related keywords (connected by 'OR')	**Dysfunction-related keywords** (connected by 'OR')	**Headache-related keywords** (connected by 'OR')	**Prevalence-related keywords** (connected by 'OR')
Temporomandibular	Arthrogenous	Headache	Prevalence
TMD	Myogenous	Migraine	Incidence
TMJ	Pain	Migraine without aura	Presence
	Dysfunction	Tension-type headache	
	Pathology	Cervicogenic headache	

Temporomandibular, dysfunction, headache and prevalence-related keywords were connected by 'AND'

3.4 Assessment of methodological quality

Studies that met eligibility criteria were assessed by two independent reviewers for methodological quality preceding their inclusion in the systematic review. A standardised critical appraisal instrument, namely the Joanna Briggs Institute Meta-Analysis of Statistics Assessment and Review Instruments (JBI-MAStARI) critical appraisal checklist for studies reporting prevalence data (Appendix A) was used for assessment of methodological quality (http://www.joannabriggs.org/sumari.html). One point was assigned to a 'yes', 'no' or 'unclear' answer to make up a score out of 10. Only studies with a combined score of six or more between the primary and secondary reviewers were included. If any disagreements ensued between the reviewers, a discussion between reviewers would take place and as well as a consultation with a third reviewer if needed.

3.5 Data collection

The number of studies found, included and excluded were shown in a PRISMA 2009 flow diagram (Liberati et al., 2009) (Figure 4.1). The standardised data extraction tool from the Joanna Briggs Institute Meta-Analysis of Statistics Assessment and Review Instrument (JBI-MAStARI) was used to extract data from the studies included in the review (Appendix C). The extracted results relevant to the review question were presented in the form of a table (Table 4.22) based on the following headings: author(s) and year of publication, type of study/design, location of study, aim(s) or purpose of study, population and sample size, outcome(s) measured, results, conclusions relevant to the systematic review question.

3.6 Data synthesis

The results from the included studies were analysed using MedCalc version 17.1, a statistical software program developed by MedCalc Software, which provides medical and statistical software, started in 1993 in Belgium (https://www.medcalc.org). With this software program, a meta-analysis was conducted by pooling the proportions from all studies. The meta-analysis was conducted by the primary researcher using the MedCalc software and the help of a statistician was not required. The headache sub-groups of interest in this study were migraine, migraine without aura, tension-type headache, concurrent migraine and tension-type headache, cervicogenic headache and chronic headache. The prevalence of TMD within each headache sub-group was then measured as well as male and female prevalence within each headache group where possible. A separate meta-analysis was then done for the data on the various headache groups occurring in people who had TMD as well as male and female prevalence within each headache sub-group where possible. Due to the pooling of the study results for meta-analysis, the I^2 value was measured as well as the 95% confidence intervals and a probability value shown for significance of effect. In order to allow for the expected high heterogeneity values from the variance of the studies, the random effects model was used for meta-analysis (Higgins et al., 2003). Forest plots of each headache sub-group and TMD were produced. Two studies could not be included in the meta-analysis and were described narratively.

3.7 Conflict of interest

There were no conflicts of interests pertaining to this study.

3.8 Ethical considerations

No human participants were involved in this study; therefore, the researcher obtained an ethical clearance waiver through the University of the Witwatersrand's Human Research Ethics Committee (Ref: W-CJ-160420-1) (Appendix D).

Chapter 4. Results

4.1 Study selection

The process of study selection was documented in the PRISMA 2009 flow diagram below (Figure 4.1). After searching all databases, 598 studies were initially identified where after duplicates were removed. A total of 161 articles were reviewed and 50 articles were deemed eligible for inclusion based on their titles and abstracts. Of the 50 studies, 26 full-text articles were assessed for eligibility and of them, 14 met the inclusion criteria and were included in this systematic review (Figure 4.1). The studies which were excluded with reasons for their exclusion are shown in appendix B.

4.2 Assessment of methodological quality

A critical appraisal of included studies was done in accordance with the Joanna Briggs Institute (JBI) critical appraisal checklist for studies reporting prevalence (Appendix A). The studies consisted of cross-sectional studies and case-control studies but all studies were assessed only for prevalence of TMD and headaches, and interventions used in the case-control studies were of no interest.

The methodological quality of the studies was sufficiently high, shown in Table 4.1 below. One study was rated 9.5/10 (Ballegaard et al., 2008), two studies were rated 9/10 (Franco et al., 2010; Silva Jr et al., 2014), two studies were rated 8.5/10 (Dahan et al., 2016; Mitrirattanakul and Merrill, 2006), five studies were rated 8/10 (Anderson et al., 2011; Ciancaglini and Radaelli, 2001; Gonçalves et al., 2013; Piekartz and Lüdtke, 2011; Tomaz-Morais et al., 2015), two studies were rated 7.5/10 (Di Paolo et al., 2009; Gonçalves et al., 2010) and one study was rated 6.5/10 (Fragoso et al., 2010). One study was not agreed upon by the second reviewer. However, a third reviewer was consulted and the combined score between reviewers was 6/10 (Plesh et al., 2011). The mean score of all the studies was 8/10.

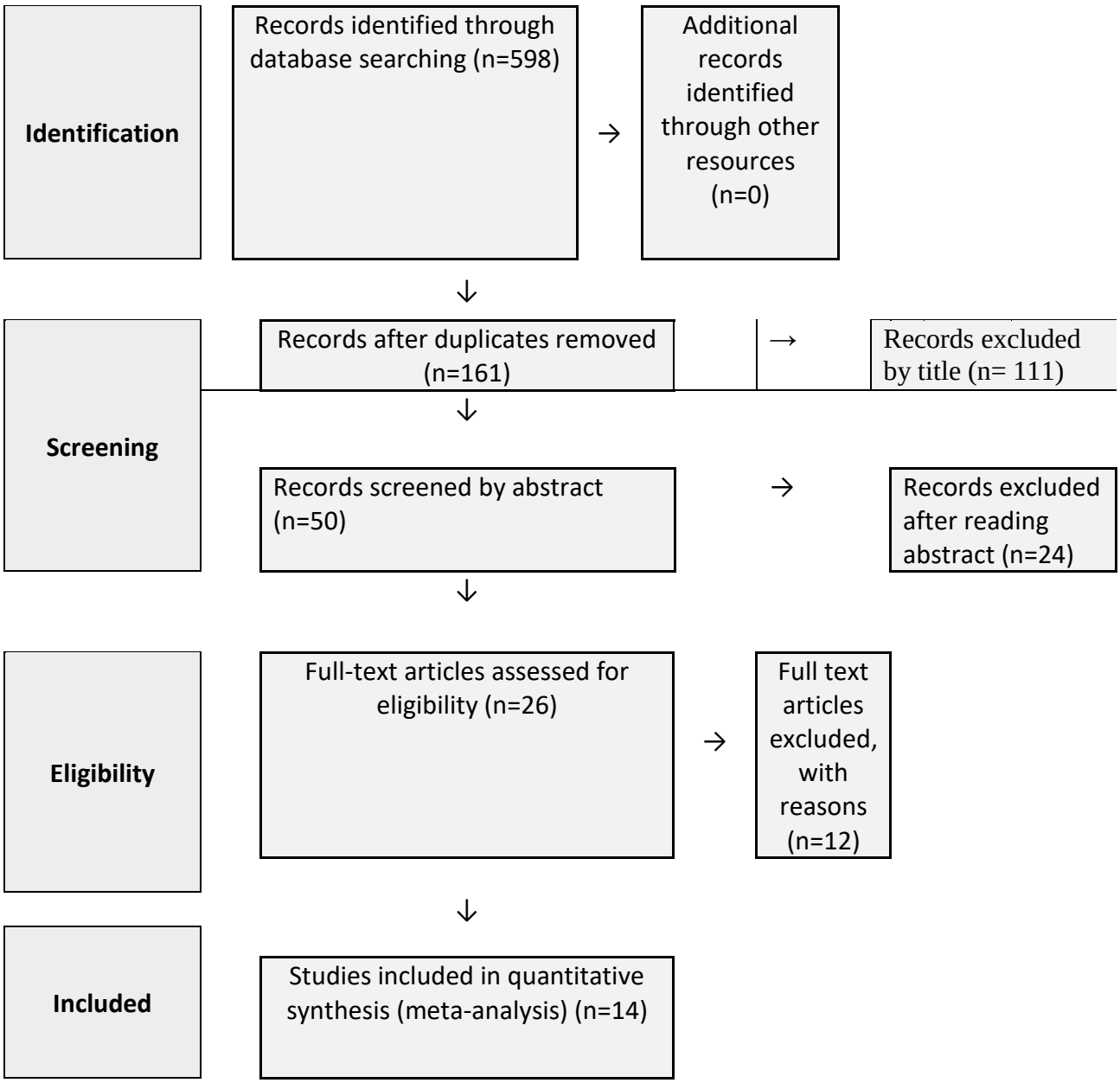

Figure 4.1 PRISMA 2009 Flow Diagram showing study selection

Table 4.1 The Joanna Briggs Institute (JBI) critical appraisal checklist for studies reporting prevalence

Authors	1. Is the sample representative of the target population?	2. Were the study participants recruited in an appropriate way?	3. Was the sample size adequate?	4. Were the study subjects and the setting described in detail?	5. Was data analysis conducted with sufficient coverage of identified sample?	6. Were objective, standard criteria used for measurement of condition?	7. Was the condition measured reliably?	8. Was there appropriate statistical analysis?	9.Are all important confounding factors/ subgroups/ differences accounted for?	10. Were sub-populations identified using objective criteria?	Total
Anderson et al (2011)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	**8**
Ballegaard et al (2008)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**9.5**
Ciancaglini and Radelli (2000)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	**8**
Dahan et al (2001)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	**8.5**
Di Paolo et al (2009)	Yes	Yes	No	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	**7.5**
Fragoso et al (2010)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	**6.5**
Franco et al (2010)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	**9**
Goncalves et al (2010)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**7.5**
Goncalves et al (2013)	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	**8**
Mitrirattanakul and Merrill (2006)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**8.5**
Plesh et al (2011)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**6**

Authors	1. Is the sample representative of the target population?	2. Were the study participants recruited in an appropriate way?	3. Was the sample size adequate?	4. Were the study subjects and the setting described in detail?	5. Was data analysis conducted with sufficient coverage of identified sample?	6. Were objective, standard criteria used for measurement of condition?	7. Was the condition measured reliably?	8. Was there appropriate statistical analysis?	9. Are all important confounding factors/ subgroups/ differences accounted for?	10. Were sub-populations identified using objective criteria?	Total
Tomaz-Morais et al (2015)	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No	**8**
Silva Jr et al (2014)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	**9**
Von Piekartz and Ludtke (2011)	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	**8**

4.3 Study characteristics

Fourteen studies, featuring 12 130 participants, were included into the meta-analysis and the mean age of all the participants was 41.45 years. All studies included in this systematic review were written in English and no translation of studies was required. Prevalence data from 14 studies were analysed from five countries, namely Brazil, USA, Italy, Denmark and the Netherlands. The bulk of data came from Brazil with six of the 14 studies conducted there. Of the 14 studies included in this systematic review, 11 were cross-sectional studies (Ballegaard et al., 2008; Ciancaglini and Radaelli, 2001; Dahan et al., 2016; Di Paolo et al., 2009; Fragoso et al., 2010; Franco et al., 2010; Gonçalves et al., 2010; Mitrirattanakul and Merrill, 2006; Plesh et al., 2011; Tomaz-Morais et al., 2015), two were case-control studies (Anderson et al., 2011; Gonçalves et al., 2013) and one was a randomised-control study (von Piekartz and Ludtke, 2011) (Table 4.22). Six studies measured the prevalence of TMD in people experiencing headache (Ballegaard et al., 2008; Fragoso et al., 2010; Gonçalves et al., 2013; Piekartz and Lüdtke, 2011; Silva Jr et al., 2014; Tomaz-Morais et al., 2015). Nine studies examined the prevalence of headache in people who had TMD (Anderson et al., 2011; Ciancaglini and Radaelli, 2001; Dahan et al., 2016; Di Paolo et al., 2009; Franco et al., 2010; Gonçalves et al., 2010; Mitrirattanakul and Merrill, 2006; Plesh et al., 2011; Silva Jr et al., 2014).

Six studies were conducted at dental outpatient clinics, five studies were conducted at headache clinics, one study was conducted at a neurology centre and one study was conducted at a physiotherapy practice (Table 4.22). All studies diagnosed headache according to the ICHD-II criteria and all TMD diagnoses were made according to RDC/TMD axis I and II and the American Academy of Orofacial Pain (AAOP). Data was extracted by way of surveys, telephonic interviews, questionnaires and assessments conducted by neurologists, dental specialists and physiotherapists.

4.4 Systematic review results

This systematic review included various meta-analyses. The results of the studies were pooled together to get a total prevalence as well as prevalence within each headache group of interest to this review. Due to the variance of the study types, heterogeneity was to be expected.

Heterogeneity is a measure of how outcomes vary between studies and it is denoted statistically as I^2 (Higgins et al., 2003). It tests the studies congruency in measuring the same outcome

and/or direction of true effect. Heterogeneity usually arises in epidemiological studies due to the variations in study type/methodology, inclusion criteria of participants, duration of studies and follow-ups, sample size of the study and outcome measures within the studies (Fletcher, 2007; Higgins et al., 2003).

The studies included in this review have a large variance in participants as well as difference in methodology (some are case-control studies and most are cross-sectional). This creates lack of homogeneity when it comes to pooling the data. However, the direction of effect of all the studies included in this review are similar, and this is shown by the 'p' value, denoting significance. The low probability (p) values shown in the meta-analysis show that although there is high heterogeneity, the direction of effect of the studies is significant (Fletcher, 2007). After pooling the results in this meta-analysis, high heterogeneity is shown but high significance of the direction of effect. Due to the high heterogeneity, the random effects model was utilised for meta-analysis, allowing for variance in true effect between each study. The results of the studies were grouped into two data groups, namely, the prevalence of TMD in people with headache and the prevalence of headache in people with TMD. Headache and TMD sub-group analysis within each data group were presented individually in the results due to high heterogeneity. Where possible, male and female prevalence was measured too.

4.4.1 Prevalence of TMD in people experiencing headache

The results are presented in accordance with the two separate objectives of this systematic review. First the results measuring the prevalence of TMD in individuals who had headache are presented along with the male and female prevalence. This is followed by the results found in the various headache sub-groups as well as the male and female prevalence within these sub-groups. Following that, the results from studies that measured the prevalence of headache occurring in individuals who had TMD are presented, as well as the male and female prevalence. The results of the various headache sub-groups measured in individuals with TMD are subsequently presented. The male and female prevalence values were presented when they could be measured within the sub-groups.

a) Prevalence of TMD in all headache types

Six studies measured the prevalence of TMD in people experiencing headache (migraine, tension-type headache, migraine without aura, concurrent migraine and tension-type headache,

cervicogenic and chronic headache) and were pooled together into the meta-analysis. The total prevalence of TMD in people experiencing any headache type was 59.28% (Table 4.2). The highest prevalence for both men and women was measured at 67.12% (Silva Jr et al., 2014) and the lowest prevalence measured was 35% (Fragoso et al., 2010). The highest prevalence measured in these studies was 88.52% (Gonçalves et al., 2013); however, this study just included female participants. The study with largest sample had the heaviest weighting and measured the prevalence of TMD in people with any headache type at 67.12% (Figure 4.2).

Table 4.2 Pooled prevalence of TMD within all headache types in males and females

Variable for total number of cases	Headache
Variable for number of positive cases	TMD

Study	Sample size	Proportion (%)	95% CI	Weight (%)	
				Fixed	Random
Ballegaard 2008	46	60.87	45.37 to 74.91	8.29	16.12
Fragoso 2010	80	35.00	24.66 to 46.48	14.29	17.10
Goncalves 2013	61	88.52	77.77 to 95.26	10.93	16.67
Piekartz 2011	43	44.18	29.07 to 60.12	7.76	15.97
Silva 2014	289	67.12	61.38 to 72.51	51.15	18.21
Tomaz-Morais 2015	42	54.76	38.67 to 70.15	7.58	15.92
Total (random effects)	561	59.28	43.81 to 73.85	100.00	100.00
Q	57.43				
DF	5				
Significance level	P < 0.0001				
I^2 (heterogeneity)	91.30%				
95% CI for I^2	83.82 to 95.32				

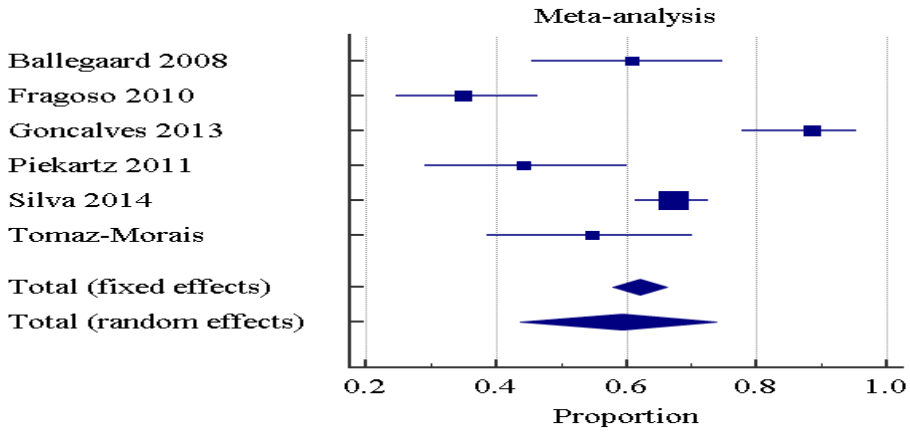

Figure 4.2 Forest plot showing the prevalence of TMD in people with any headache type

b) Prevalence of TMD in males experiencing any headache type

After pooling five studies together for meta-analysis, the total prevalence of TMD in males experiencing headache was 55.33% (Table 4.3). The highest prevalence measured was 77.77% (Ballegaard et al., 2008), which was significantly higher than the other prevalence results (Table 4.3) (Figure 4.3). The lowest prevalence was 40% (Fragoso et al., 2010). There was not a large amount of heterogeneity measured among these studies (I^2 was 30.35%).

Table 4.3 Prevalence of TMD within all headache types in males

Variable for total number of cases	Males with headache
Variable for number of positive cases	TMD

Study	Sample size	Proportion (%)	95% CI	Weight (%)	
				Fixed	Random
Ballegaard 2008	9	77.77	39.99 to 97.18	9.71	12.30
Fragoso 2010	10	40.00	12.15 to 73.76	10.68	13.29
Piekartz 2011	16	43.75	19.75 to 70.12	16.50	18.51
Silva 2014	38	65.78	48.64 to 80.36	37.86	31.22
Tomaz-Morais 2015	25	48.00	27.79 to 68.69	25.24	24.68
Total (random effects)	98	55.33	43.31 to 67.03	100.00	100.00
Q	5.74				
DF	4				
Significance level	P = 0.21				
I^2 (heterogeneity)	30.35%				
95% CI for I^2	0.00 to 73.16				

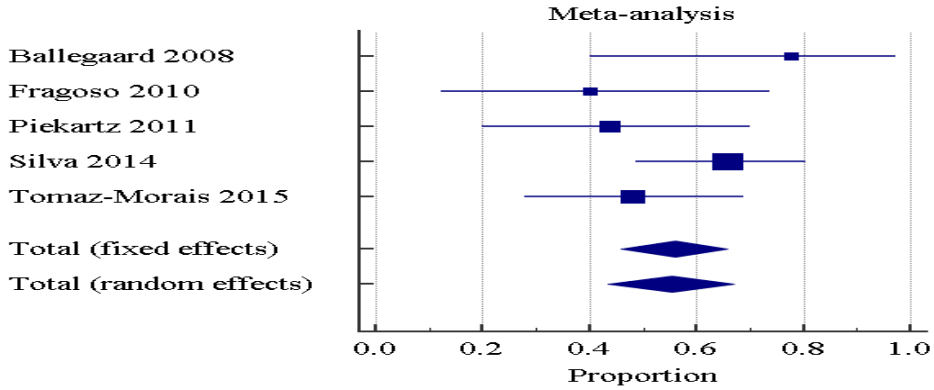

Figure 4.3 Forest plot showing the prevalence of TMD in males with any type of headache

c) Prevalence of TMD in females experiencing any headache type

The total prevalence of TMD in women with any headache type was measured at 60.11% after pooling six studies together (Table 4.4). The highest prevalence was 88.52% including female participants only (Gonçalves et al., 2013). The lowest prevalence of TMD measured in females with headache was 34.28% (Fragoso et al., 2010). Two studies measured very similar prevalence values of 64.70% and 66.93% despite them having extremely large differences in their sample sizes (Silva Jr et al., 2014; Tomaz-Morais et al., 2015) (Table 4.4) (Figure 4.4).

Table 4.4 Prevalence of TMD in females with any headache type

Variable for total number of cases	Females with headache
Variable for number of positive cases	TMD

Study	Sample size	Proportion (%)	95% CI	Weight (%)	
				Fixed	Random
Ballegaard 2008	37	56.75	39.48 to 72.90	8.10	16.43
Fragoso 2010	70	34.28	23.34 to 46.60	15.14	17.64
Goncalves 2013	61	88.52	77.77 to 95.26	13.22	17.42
Piekartz 2011	27	44.44	25.48 to 64.67	5.97	15.61
Silva 2014	251	66.93	60.73 to 72.72	53.73	18.78
Tomaz-Morais 2015	17	64.70	38.32 to 85.79	3.84	14.12
Total (random effects)	463	60.11	43.42 to 75.67	100.00	100.00
Q	52.02				
DF	5				
Significance level	P < 0.0001				
I^2 (heterogeneity)	90.39%				
95% CI for I^2	81.82 to 94.92				

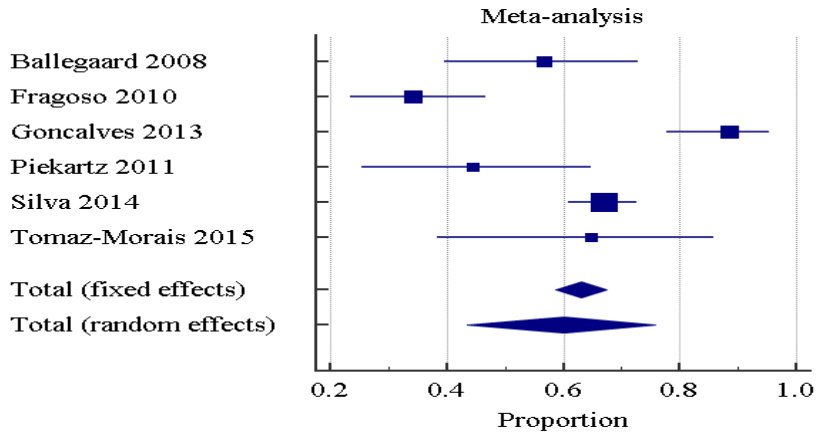

Figure 4.4 Forest plot showing the prevalence of TMD in females with any headache type

4.4.2 Sub-group meta-analysis: the prevalence of TMD in individuals with each specific headache type

Due to the high heterogeneity of the pooled studies, each sub-group of headache type of interest in this study was analysed individually. The total prevalence of each headache type of interest, and the male and female prevalence were measured.

a) Prevalence of TMD in people experiencing migraine

Four studies measured the prevalence of TMD occurring in people experiencing migraine, and a total prevalence of 63.28% was found (Table 4.5). The highest prevalence was 86.84% (Gonçalves et al., 2013) in a study measuring prevalence of TMD in women with migraine. This study also had the heaviest weighting, most likely to due to it having the largest sample size in this group of studies (Figure 4.5). The lowest prevalence was recorded at 36.36% (Fragoso et al., 2010), almost half the total prevalence found in the total population of people experiencing migraine.

Table 4.5 Prevalence of TMD in people who had migraine

Variable for total number of cases	Migraine
Variable for number of positive cases	TMD

Study	Sample size	Proportion (%)	95% CI	Weight (%)	
				Fixed	Random
Ballegaard 2008	15	53.33	26.58 to 78.73	16.00	23.26
Fragoso 2010	22	36.36	17.19 to 59.34	23.00	25.01
Goncalves 2013	38	86.84	71.91 to 95.58	39.00	26.91
Tomaz-Morais 2015	21	71.42	47.82 to 88.71	22.00	24.82
Total (random effects)	96	63.28	38.91 to 84.49	100.00	100.00
Q	18.06				
DF	3				
Significance level	P = 0.0004				
I^2 (heterogeneity)	83.39%				
95% CI for I^2	57.81 to 93.46				

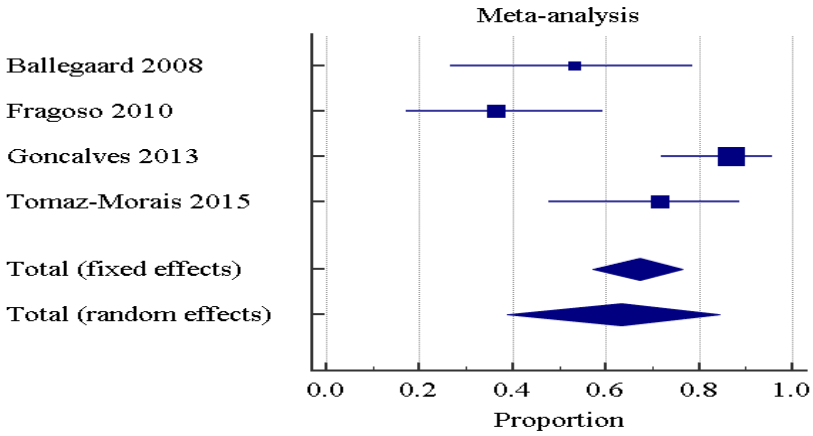

Figure 4.5 Forest plot showing the prevalence of TMD in people who had migraine

b) Prevalence of TMD in people experiencing tension-type headache

Two studies examined the prevalence of TMD in people who had simultaneous tension-type headache, and the pooled prevalence of these studies was 41.14% (Table 4.6). The highest prevalence was 45.45% (Ballegaard et al., 2008) and the lowest prevalence measured was 38.09% (Tomaz-Morais et al., 2015). All the studies were homogenous (I^2 =0%) and these

results show an accurate appraisal of the prevalence of TMD in people with tension-type headache due to the lack of heterogeneity among these studies (Figure 4.6).

Table 4.6 Prevalence of TMD in people who had tension-type headache

Variable for total number of cases	Tension-type headache
Variable for number of positive cases	TMD

Study	Sample size	Proportion (%)	95% CI	Weight (%)	
				Fixed	Random
Ballegaard 2008	11	45.45	16.74 to 76.62	35.29	35.29
Tomaz-Morais 2015	21	38.09	18.10 to 61.56	64.71	64.71
Total (fixed effects)	32	41.14	24.61 to 59.27	100.00	100.00
Total (random effects)	32	41.14	25.40 to 57.87	100.00	100.00
Q	0.16				
DF	1				
Significance level	P = 0.68				
I^2 (heterogeneity)	0.00%				
95% CI for I^2	0.00 to 0.00				

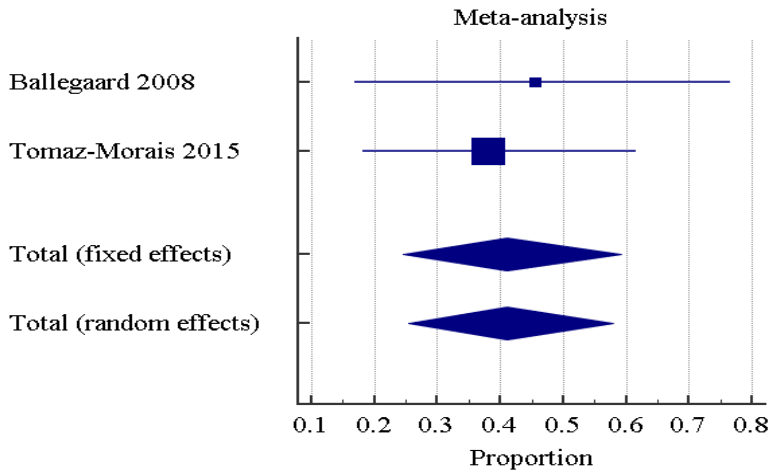

Figure 4.6 Forest plot showing the prevalence of TMD in people who had tension-type headache

c) Prevalence of TMD in people experiencing migraine without aura

Most of the studies referred to 'migraine' except two studies which specified 'migraine without aura'. The total prevalence of TMD in people who had migraine without aura was 55.56%. The

lowest prevalence was 33.33% (Fragoso et al., 2010) and the highest prevalence measured was 77.77% (Tomaz-Morais et al., 2015). I^2 was 87.32%, showing a large variance between the two studies (Table 4.7) (Figure 4.7).

Table 4.7 Prevalence of TMD in people who had migraine without aura

Variable for total number of cases	Migraine without aura
Variable for number of positive cases	TMD

Study	Sample size	Proportion (%)	95% CI	Weight (%)	
				Fixed	Random
Fragoso 2010	21	33.33	14.58 to 56.96	53.66	50.46
Tomaz-Morais 2015	18	77.77	52.36 to 93.59	46.34	49.54
Total (random effects)	39	55.56	15.90 to 91.34	100.00	100.00
Q	7.88				
DF	1				
Significance level	P = 0.0050				
I^2 (heterogeneity)	87.32%				
95% CI for I^2	50.51 to 96.75				

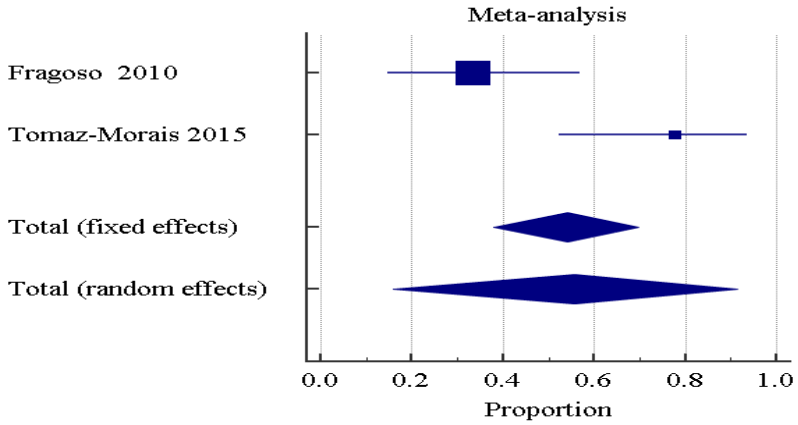

Figure 4.7 Forest plot showing the prevalence of TMD in people who had migraine without aura

d) Prevalence of TMD in people experiencing cervicogenic headache

The total prevalence measured for TMD within people experiencing cervicogenic headache was 44.67% (Table 4.8). Only two studies included cervicogenic headache and both had small

sample sizes. The highest prevalence of TMD found in people experiencing cervicogenic headache was measured at 50% and the lowest 44.18% (Fragoso et al., 2010; von Piekartz and Ludtke, 2011) (Table 4.8) (Figure 4.8). One study exclusively examined the prevalence of TMD within people who had cervicogenic headache and found 44,18% of the participants had TMD (von Piekartz and Ludtke, 2011) (Table 4.8). The study with the smallest sample size of only two participants with cervicogenic headache found a 50% prevalence of TMD (Fragoso et al., 2010) but the study by von Piekartz and Ludtke (2011) had a much heavier weighting and more accurate prevalence measurement (Figure 4.8). No heterogeneity was found between these studies.

Table 4.8 Prevalence of TMD in people who had cervicogenic headache

Variable for total number of cases	Cervicogenic headache
Variable for number of positive cases	TMD

Study	Sample size	Proportion (%)	95% CI	Weight (%)	
				Fixed	Random
Fragoso 2010	2	50.00	1.25 to 98.74	6.38	6.38
Von Piekartz 2011	43	44.18	29.07 to 60.12	93.62	93.62
Total (fixed effects)	45	44.67	30.17 to 59.88	100.00	100.00
Total (random effects)	45	44.67	30.87 to 58.91	100.00	100.00
Q	0.036				
DF	1				
Significance level	P = 0.84				
I^2 (heterogeneity)	0.00%				
95% CI for I^2	0.00 to 0.00				

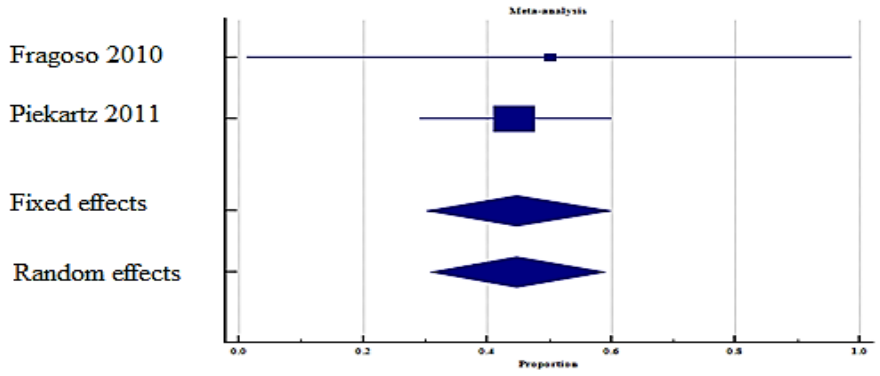

Figure 4.8 Forest plot showing the prevalence of TMD in people who had cervicogenic headache

e) Prevalence of TMD in people experiencing chronic headache

Chronic headaches were not specified headache types, but were headaches experienced on more than 15 days per month, for three months or more (IHS, 2013). Chronic headache could have included chronic migraine, chronic tension-type headache, chronic cervicogenic headache or chronic migraine without aura. When chronic headache included medication overuse headache, it was excluded from the meta-analysis. Three studies measured the prevalence of TMD in people who had chronic headache, and measured a pooled result of 64.16% (95% CI 25.79 to 94.09) (Table 4.9). The highest prevalence measured was 91.30% in a female-only study (Gonçalves et al., 2013) and the second-highest prevalence was 63.63% in a study including both men and women (Tomaz-Morais et al., 2015) (Table 4.9). The lowest prevalence was measured at 35.55% (Fragoso et al., 2010), which was a dramatically lower prevalence value compared to the other two studies (Figure 4.9) (Table 4.9).

Table 4.9 Prevalence of TMD in people who had chronic headache

Variable for total number of cases	Chronic headache
Variable for number of positive cases	TMD

Study	Sample size	Proportion (%)	95% CI	Weight (%)	
				Fixed	Random
Fragoso 2010	45	35.55	21.86 to 51.22	56.10	35.19
Goncalves 2013	23	91.30	71.96 to 98.92	29.27	33.74
Tomaz-Morais 2015	11	63.63	30.79 to 89.07	14.63	31.07
Total (random effects)	79	64.16	25.79 to 94.09	100.00	100.00
Q	22.99				
DF	2				
Significance level	P < 0.0001				
I^2 (heterogeneity)	91.30%				
95% CI for I^2	77.56 to 96.63				

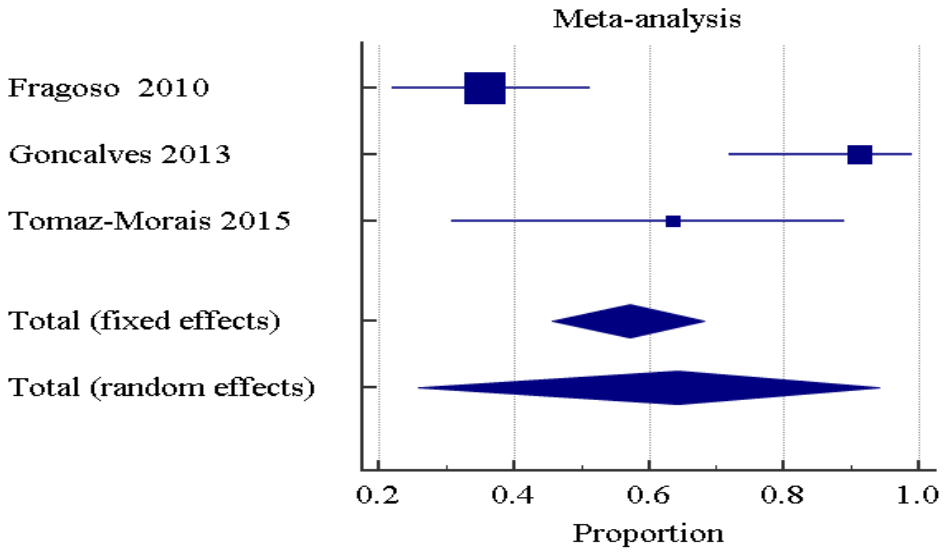

Figure 4.9 Forest plot showing the prevalence of TMD in people who had chronic headache

4.4.3 Prevalence of headache in people experiencing TMD

a) All headache types in people experiencing TMD

After pooling nine studies into meta-analysis, the total prevalence of headache in people experiencing TMD was 63.84% (Table 4.10). The highest prevalence measured was 97.77% (Di Paolo et al., 2009) and the lowest prevalence was 27.44% (Ciancaglini and Radaelli, 2001).

The largest study in the group with 8964 participants and the heaviest weighting, measured the prevalence at 52.49% (Plesh et al., 2011) which was most likely the most reflective population prevalence measured in the group (Figure 4.10) (Table 4.10). The high I^2 value of 98.35% showed a large variance amongst the studies, due to study type, participant numbers and setting of the studies. However, the low p-value shows a significant direction of effect, with headache being highly prevalent in people who had TMD (Table 4.10) (Figure 4.10).

Table 4.10 Prevalence of headache in people who had TMD

Variable for total number of cases	TMD
Variable for number of positive cases	Headache

Study	Sample size	Proportion (%)	95% CI	Weight (%)	
				Fixed	Random
Anderson 2011	395	78.22	73.82 to 82.20	3.42	11.46
Ciancaglini 2001	266	27.44	22.17 to 33.22	2.31	11.33
Dahan 2016	180	46.11	38.66 to 53.68	1.56	11.15
Di Paolo 2009	45	97.77	88.23 to 99.94	0.40	9.74
Franco 2010	158	82.27	75.41 to 87.88	1.37	11.08
Goncalves 2010	1148	38.58	35.76 to 41.47	9.92	11.64
Mitrirattanakul 2006	337	72.99	67.92 to 77.66	2.92	11.42
Plesh 2011	8964	52.49	51.45 to 53.53	77.43	11.72
Silva 2014	76	71.05	59.51 to 80.88	0.67	10.45
Total (random effects)	11569	63.84	53.09 to 73.94	100.00	100.00
Q	483.96				
DF	8				
Significance level	P < 0.0001				
I^2 (heterogeneity)	98.35%				
95% CI for I^2	97.78 to 98.77				

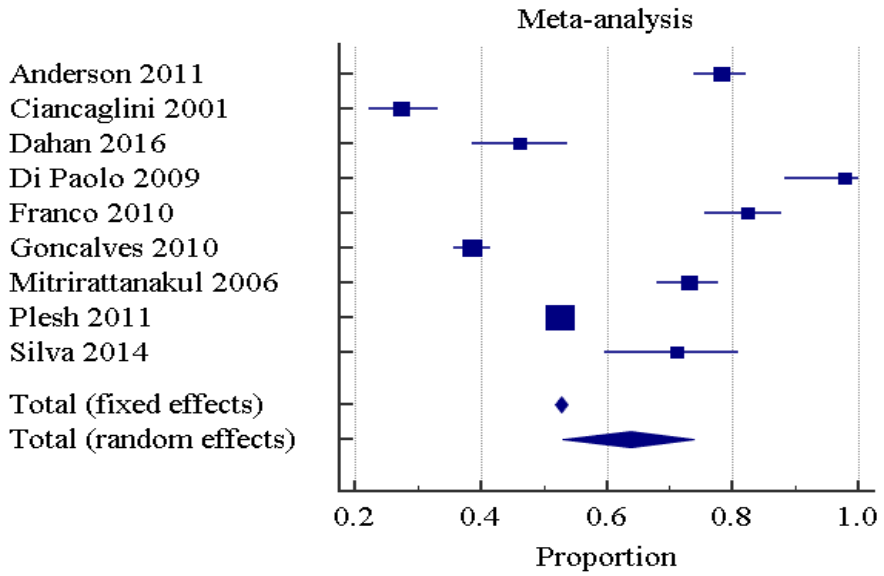

Figure 4.10 Forest plot showing the prevalence of headache in people who had TMD

b) Prevalence of headache in males experiencing TMD

Six studies measuring the prevalence of headache in males who had TMD found the total prevalence in males to be 61.98% (Table 4.11). The highest prevalence found was 83.33% (Di Paolo et al., 2009) by a study with the smallest sample size of males (Table 4.11). The largest population-based study consisting of 4302 male participants, measured the prevalence of headache in males with TMD at 52.51% (CI 51.00 to 54.01) (Plesh et al., 2011), measuring an accurate estimate of the male prevalence due to the scale of this population-based study. Two studies measured an almost identical prevalence of 73.01% and 73.68% (Mitrirattanakul and Merrill, 2006; Silva Jr et al., 2014), both with varying sample sizes (Table 4.11). Again, a moderately high I^2 and low p-value depicted noticeable variance amongst the studies but significant direction of effect within these studies (Figure 4.11).

Table 4.11 Prevalence of headache in males with TMD

Variable for total number of cases	TMD
Variable for number of positive cases	Headache/Males

Study	Sample size	Proportion (%)	95% CI	Weight (%)	
				Fixed	Random
Anderson 2011	50	64.00	49.19 to 77.08	1.14	18.63
Dahan 2016	31	45.16	27.31 to 63.96	0.71	15.74
Di Paolo 2009	6	83.33	35.87 to 99.57	0.16	6.33
Mitrirattanakul 2006	63	73.01	60.34 to 83.42	1.43	19.88
Plesh 2011	4302	52.51	51.00 to 54.01	96.11	26.82
Silva 2014	19	73.68	48.79 to 90.85	0.45	12.60
Total (random effects)	4471	61.98	51.44 to 71.98	100.00	100.00
Q	19.88				
DF	5				
Significance level	P = 0.0013				
I^2 (heterogeneity)	74.85%				
95% CI for I^2	43.00 to 88.91				

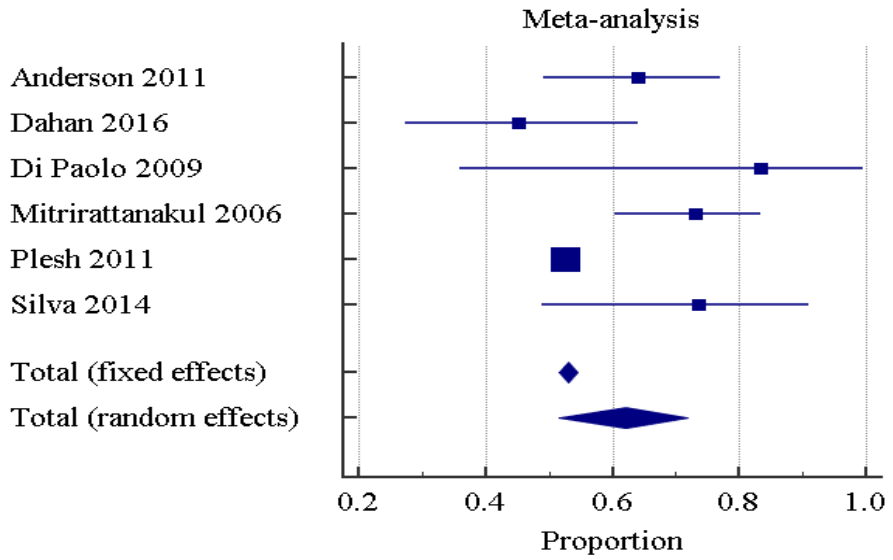

Figure 4.11 Forest plot showing the prevalence of headache in males who had TMD

c) Prevalence of headache in females experiencing TMD

The total prevalence of headache in women who had TMD was 71.17% (Table 4.12). The highest prevalence was 97.43% (Di Paolo et al., 2009), which was significantly higher than the other prevalence values measured. The lowest prevalence recorded was 46.30% (Dahan et al., 2016), which was noticeably lower than the other prevalence measured. The largest study in this group measured the prevalence of headache in females with TMD at 52.49%, which was almost identical to the male prevalence of 52.51% measured in the same study (Plesh et al., 2011) (Table 4.11) (Table 4.12). Two studies measured very similar prevalence of headache in females with TMD (71.93% and 72.62%) (Mitrirattanakul and Merrill, 2006; Silva Jr et al., 2014) and is in parallel to the prevalence measured for males by these two studies (Table 4.11) (Table 4.12). The large variance within these studies can be seen in the forest plot (Figure 4.12) but the low p-value showed that headache was prevalent in females with TMD (Table 4.12).

Table 4.12 Prevalence of headache in females who had TMD

Variable for total number of cases	TMD
Variable for number of positive cases	Headache females

Study	Sample size	Proportion (%)	95% CI	Weight (%)	
				Fixed	Random
Anderson 2011	345	80.29	75.69 to 84.35	6.26	17.39
Dahan 2016	149	46.30	38.11 to 54.65	2.71	16.92
Di Paolo 2009	39	97.43	86.52 to 99.93	0.72	14.93
Mitrirattanakul 2006	274	72.62	66.93 to 77.81	4.97	17.30
Plesh 2011	4661	52.49	51.05 to 53.94	84.29	17.75
Silva 2014	57	71.93	58.45 to 83.02	1.05	15.71
Total (random effects)	5525	71.17	56.87 to 83.59	100.00	100.00
Q	209.99				
DF	5				
Significance level	P < 0.0001				
I^2 (heterogeneity)	97.62%				
95% CI for I^2	96.38 to 98.43				

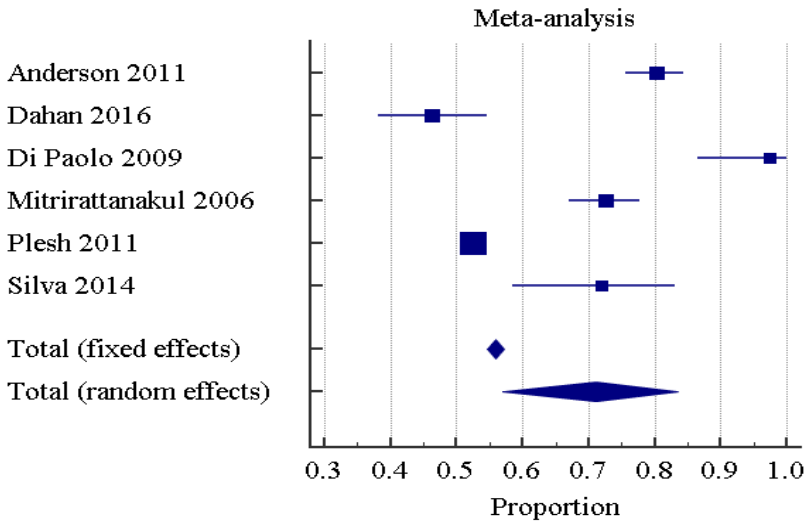

Figure 4.12 Forest plot showing the prevalence of headache in females with TMD

4.4.4 Sub-group meta-analysis: the prevalence of each specific headache type in individuals with TMD

Due to the high heterogeneity of the pooled studies, each sub-group of headache type of interest in this study was analysed individually. The total prevalence of each headache type of interest in people experiencing TMD was measured, as well as the male and female prevalence where possible.

a) Prevalence of migraine in people experiencing TMD

Seven studies were pooled together and measured the total prevalence of migraine in people who had TMD at 41.98% (Table 4.13). The highest prevalence measured was 72.99% (Mitrirattanakul and Merrill, 2006). This study compared headaches in people with TMD versus without TMD and there was a significantly high prevalence in those with TMD (Mitrirattanakul and Merrill, 2006). The lowest prevalence measured was 20% (Di Paolo et al., 2009) by a study with a small sample size where most of the participants had TMD. The heavy weighting and large sample size of the study by Plesh et al (2011) reflected good precision in the prevalence estimate of 52.49% (Plesh et al., 2011). The variance among the studies was demonstrated by a high I^2 value of 98.80%. Although the I^2 value was high, the low p-value showed a significant prevalence of migraine occurring in people who had TMD.

Table 4.13 Prevalence of migraine in people who had TMD

Variable for total number of cases	TMD
Variable for number of positive cases	Migraine

Study	Sample size	Proportion (%)	95% CI	Weight (%)	
				Fixed	Random
Dahan 2016	180	46.11	38.66 to 53.68	1.66	14.42
Di Paolo 2009	45	20.00	9.57 to 34.59	0.42	13.01
Franco 2010	158	53.16	45.07 to 61.13	1.46	14.34
Goncalves 2010	1148	23.34	20.92 to 25.90	10.53	14.88
Mitrirattanakul 2006	337	72.99	67.92 to 77.66	3.10	14.67
Plesh 2011	8964	52.49	51.45 to 53.53	82.13	14.95
Silva 2014	76	25.00	15.77 to 36.25	0.71	13.73
Total (random effects)	10908	41.98	28.27 to 56.37	100.00	100.00
Q	500.91				
DF	6				
Significance level	P < 0.0001				
I^2 (heterogeneity)	98.80%				
95% CI for I^2	98.37 to 99.12				

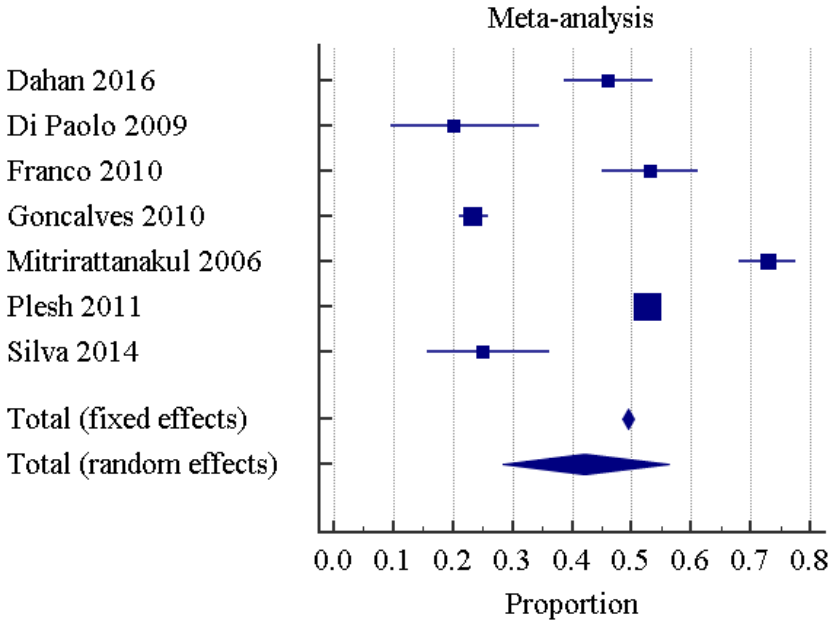

Figure 4.13 Forest plot showing the prevalence of migraine in people who had TMD

b) Prevalence of migraine in males experiencing TMD

The total prevalence of migraine in men who had TMD was 50.34%. Five studies were pooled together to derive this prevalence (Table 4.14). The highest prevalence of migraine in men who had TMD was 73.01%, from a study based on a population with orofacial pain (Mitrirattanakul and Merrill, 2006). The lowest prevalence measured was 26.31% (Silva Jr et al., 2014) and was significantly lower than the other prevalence values measured (Table 4.14) (Figure 4.14). One study measured the prevalence of migraine in males experiencing TMD at 52.51%, which was the most similar to the total prevalence of migraine in males who had TMD (Plesh et al., 2011) (Table 4.14).

Table 4.14 Prevalence of migraine in males who had TMD

Variable for total number of cases	TMD
Variable for number of positive cases	Males with migraine

Study	Sample size	Proportion (%)	95% CI	Weight (%)	
				Fixed	Random
Dahan 2016	31	45.16	27.31 to 63.96	0.72	19.95
Di Paolo 2009	6	33.33	4.32 to 77.72	0.16	8.90
Mitrirattanakul 2006	63	73.01	60.34 to 83.42	1.45	24.16
Plesh 2011	4302	52.51	51.00 to 54.01	97.22	30.48
Silva 2014	19	26.31	9.14 to 51.20	0.45	16.51
Total (random effects)	4421	50.34	37.36 to 63.30	100.00	100.00
Q	18.12				
DF	4				
Significance level	P = 0.0012				
I^2 (heterogeneity)	77.93%				
95% CI for I^2	46.94 to 90.82				

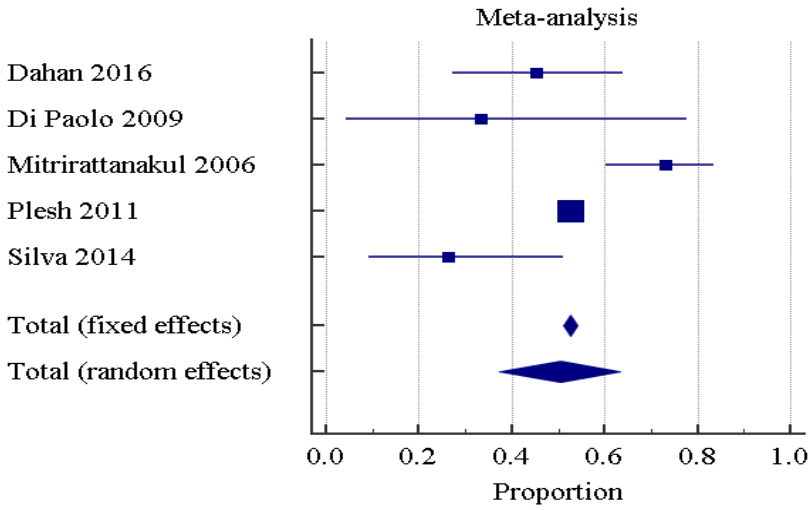

Figure 4.14 Forest plot showing the prevalence of migraine in males who had TMD

c) Prevalence of migraine in females experiencing TMD

The prevalence of migraine occurring simultaneously as TMD in women was measured at 44.48% (Table 4.15). This is slightly lower than the male prevalence of 50.34% (Table 4.14). The highest prevalence measured was 72.62% (Mitrirattanakul and Merrill, 2006) and the lowest prevalence found was 17.94% (Di Paolo et al., 2009), which was distinctly lower than the other prevalence values measured (Table 4.15). The study by Plesh et al (2011) again measured very similar prevalence of migraine in males and females who had TMD (52.51% and 52.49% respectively) (Plesh et al., 2011) (Table 4.14) (Table 4.15) (figure 4.15).

Table 4.15 Prevalence of migraine in females who had TMD

Variable for total number of cases	TMD
Variable for number of positive cases	Migraine females

Study	Sample size	Proportion (%)	95% CI	Weight (%)	
				Fixed	Random
Dahan 2016	149	46.30	38.11 to 54.65	2.89	20.66
Di Paolo 2009	39	17.94	7.53 to 33.53	0.77	17.24
Mitrirattanakul 2006	274	72.62	66.93 to 77.81	5.30	21.36
Plesh 2011	4661	52.49	51.05 to 53.94	89.91	22.20
Silva 2014	57	26.31	15.53 to 39.66	1.12	18.54
Total (random effects)	5180	44.48	31.38 to 57.99	100.00	100.00
Q	87.64				
DF	4				
Significance level	P < 0.0001				
I^2 (heterogeneity)	95.44%				
95% CI for I^2	91.92 to 97.42				

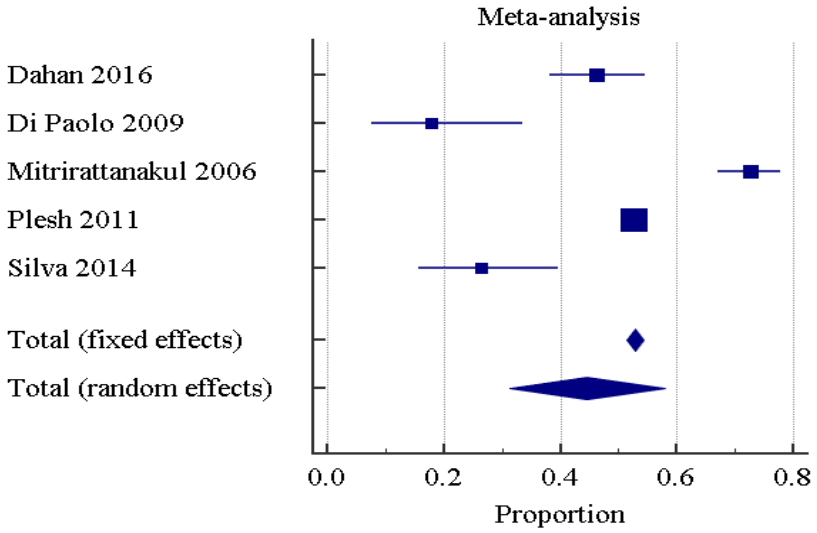

Figure 4.15 Forest plot showing the prevalence of migraine in females who had TMD

d) Prevalence of tension-type headache in people experiencing TMD

The results of five studies were pooled together and a total prevalence of tension-type headache in people who had TMD was found to be 30.13% (Table 4.16). The highest prevalence measured was 61.77% (Anderson et al., 2011) and the lowest prevalence found was 8.88% (Di Paolo et al., 2009) (Table 4.16) (Figure 4.16). This study by Di Paolo et al (2009) had a very

small sample size, set in a dental clinic, and the results are not as representative of the prevalence as the larger population-based studies (Di Paolo et al., 2009). There was a large variance among the prevalence results from these studies but the study by Franco et al (2010) had the closest prevalence (29.11%) to the total prevalence measured (30.13%) (Franco et al., 2010) (Table 4.16).

Table 4.16 Prevalence of tension-type headache in people who had TMD

Variable for total number of cases	TMD
Variable for number of positive cases	Tension-type headache

Study	Sample size	Proportion (%)	95% CI	Weight (%)	
				Fixed	Random
Anderson 2011	395	61.77	56.78 to 66.58	21.67	20.33
Di Paolo 2009	45	8.88	2.47 to 21.22	2.52	19.34
Franco 2010	158	29.11	22.16 to 36.86	8.70	20.13
Goncalves 2010	1148	12.28	10.43 to 14.32	62.89	20.42
Silva 2014	76	46.05	34.54 to 57.87	4.21	19.78
Total (random effects)	1822	30.13	9.31 to 56.64	100.00	100.00
Q	377.62				
DF	4				
Significance level	P < 0.0001				
I^2 (heterogeneity)	98.94%				
95% CI for I^2	98.48 to 99.26				

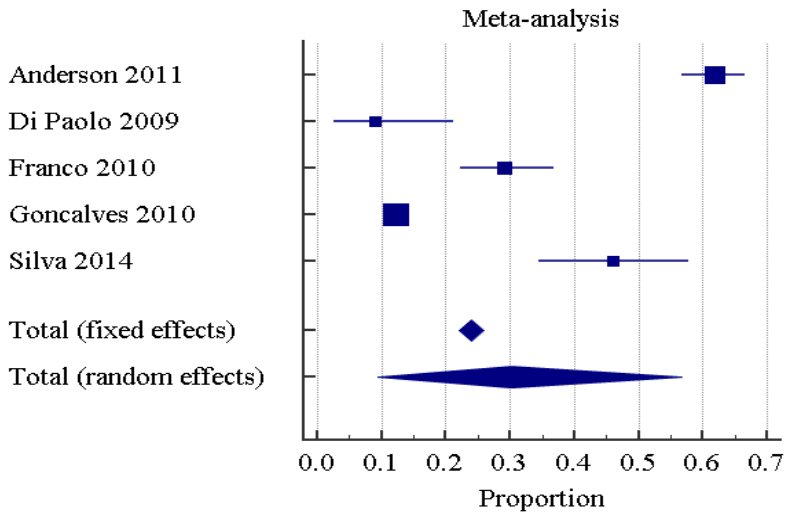

Figure 4.16 Forest plot showing the prevalence of tension-type headache in people who had TMD

e) Prevalence of tension-type headche in males experiencing TMD

The pooled prevalence of tension-type headache in males with TMD was 45.04% (Table 4.17) (Figure 4.17). Two studies measured similar prevalence values of tension-type headache in males who had TMD at 47.36% (Silva Jr et al., 2014) and 48% (Anderson et al., 2011), while the low prevalence of 16.66% was measured by a study that had only six male participants with TMD and concurrent tension-type headache (Di Paolo et al., 2009).

Table 4.17 Prevalence of tension-type headache in males with TMD

Variable for total number of cases	TMD
Variable for number of positive cases	Males with tension-type headache

Study	Sample size	Proportion (%)	95% CI	Weight (%)	
				Fixed	Random
Anderson 2011	50	48.00	33.66 to 62.58	65.38	63.12
Di Paolo 2009	6	16.66	0.42 to 64.12	8.97	9.84
Silva 2014	19	47.36	24.44 to 71.13	25.64	27.03
Total (fixed effects)	75	45.30	33.99 to 56.98	100.00	100.00
Total (random effects)	75	45.04	33.59 to 56.76	100.00	100.00
Q	2.12				
DF	2				
Significance level	P = 0.34				
I^2 (heterogeneity)	5.79%				
95% CI for I^2	0.00 to 96.84				

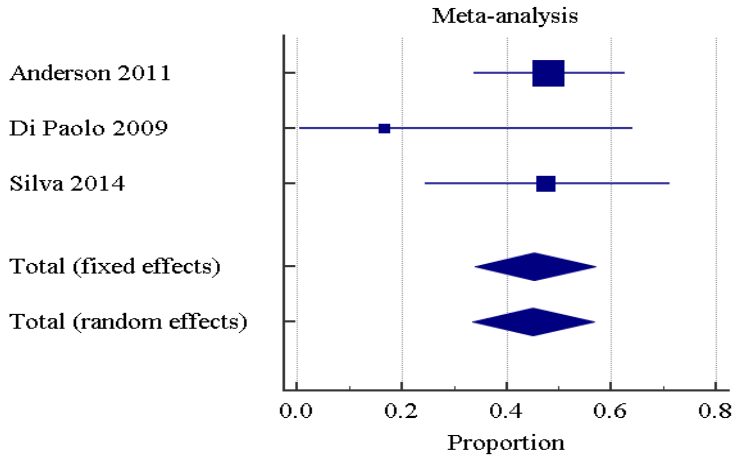

Figure 4.17 Forest plot showing the prevalence of tension-type headache in males with TMD

f) Prevalence of tension-type headache in females experiencing TMD

The three studies included for meta-analysis for this sub-group showed a total prevalence of tension-type headache in females with TMD of 37.73% (Table 4.18). The prevalence of tension-type headache in females with TMD was lower than the male prevalence of 45.04% (Table 4.17). The study with the largest sample size measured the highest prevalence of 63.76% (Anderson et al., 2011) and the study with the smallest sample size measured the lowest prevalence of 7.69% (Di Paolo et al., 2009) for females with TMD who were experiencing tension-type headache (Table 4.18) (Figure 4.18).

Table 4.18 Prevalence of tension-type headache in females with TMD

Variable for total number of cases	TMD
Variable for number of positive cases	Females with tension-type headache

Study	Sample size	Proportion (%)	95% CI	Weight (%)	
				Fixed	Random
Anderson 2011	345	63.76	58.45 to 68.84	77.93	34.47
Di Paolo 2009	39	7.69	1.61 to 20.87	9.01	32.42
Silva 2014	57	45.61	32.35 to 59.34	13.06	33.11
Total (random effects)	441	37.73	9.93 to 71.01	100.00	100.00
Q	58.78				
DF	2				
Significance level	P < 0.0001				
I^2 (heterogeneity)	96.60%				
95% CI for I^2	92.96 to 98.36				

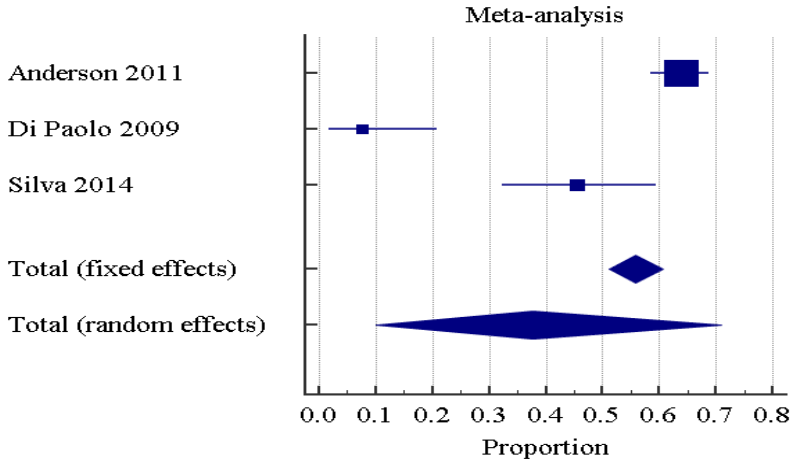

Figure 4.18 Forest plot showing the prevalence of tension-type headache in females with TMD

g) Prevalence of chronic headache in people experiencing TMD

The total prevalence of chronic headache in people who had TMD was 8.85% after the summation of the prevalence of three studies (Table 4.19). The highest prevalence measured was 16.45% (Anderson et al., 2011) and the lowest prevalence was a 2.96% (Gonçalves et al., 2010). The study with largest participant number had the heaviest weighting and measured the lowest prevalence (2.96%), which could reflect a more accurate appraisal of the prevalence of chronic headache in people who had TMD (Gonçalves et al., 2010) (Figure.4.19). There was a low prevalence of chronic headache seen in people with TMD (Table 4.19).

Table 4.19 Prevalence of chronic headache in people with TMD

Variable for total number of cases	TMD
Variable for number of positive cases	Chronic headache

Study	Sample size	Proportion (%)	95% CI	Weight (%)	
				Fixed	Random
Anderson 2011	395	16.45	12.93 to 20.48	24.89	34.91
Di Paolo 2009	45	8.88	2.47 to 21.22	2.89	29.63
Goncalves 2010	1148	2.96	2.06 to 4.11	72.22	35.45
Total (random effects)	1588	8.85	1.24 to 22.34	100.00	100.00
Q	71.69				
DF	2				
Significance level	P < 0.0001				
I^2 (inconsistency)	97.21%				
95% CI for I^2	94.47 to 98.59				

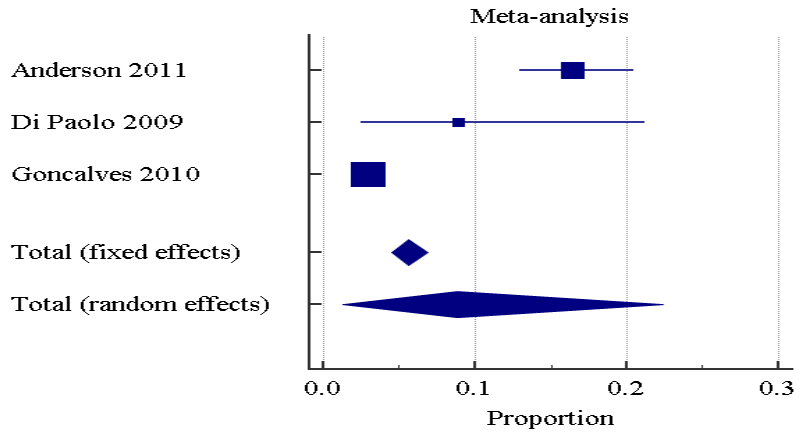

Figure 4.19 Forest plot showing the prevalence of chronic headache in people with TMD

h) Prevalence of chronic headache in males experiencing TMD

Two studies were included in the meta-analysis and determined the prevalence of chronic headache in males with TMD to be 17.15% (Table 4.20). The two studies included in this sub-group analysis had large differences in their sample size, yet measured almost identical prevalence values of 16% (Anderson et al., 2011) and 16.66% (Di Paolo et al., 2009) (Table 4.20) (Figure 4.20).

Table 4.20 prevalence of chronic headache in males with TMD

Variable for total number of cases	TMD
Variable for number of positive cases	Males with chronic headache

Study	Sample size	Proportion (%)	95% CI	Weight (%)	
				Fixed	Random
Anderson 2011	50	16.00	7.17 to 29.11	87.93	87.93
Di Paolo 2009	6	16.66	0.42 to 64.12	12.07	12.07
Total (fixed effects)	56	17.15	8.52 to 29.33	100.00	100.00
Total (random effects)	56	17.15	8.64 to 27.83	100.00	100.00
Q	0.07554				
DF	1				
Significance level	P = 0.7834				
I^2 (heterogeneity)	0.00%				
95% CI for I^2	0.00 to 0.00				

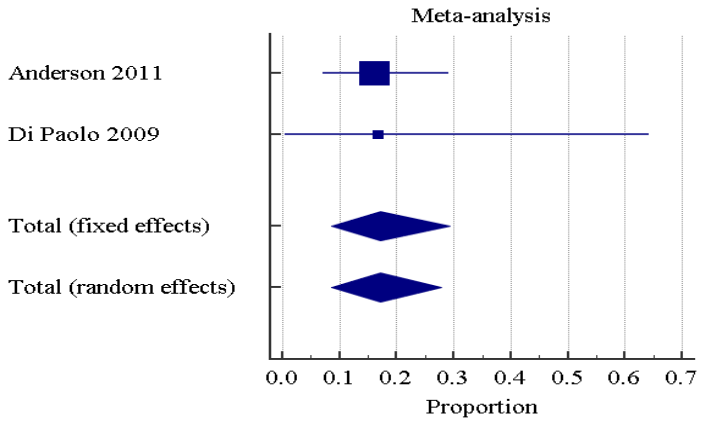

Figure 4.20 Forest plot of the prevalence of chronic headache in males with TMD

i) Prevalence of chronic headache in females experiencing TMD

A low prevalence of 13.94% was measured for females with TMD who were experiencing chronic headache, after pooling two studies (Table 4.21). The highest prevalence recorded was 16.52% (Anderson et al., 2011) and lowest prevalence was 7.69% (Di Paolo et al., 2009) (Table 4.21) (Figure 4.21). The prevalence of chronic headache in females with TMD was lower than that of males (Table 4.20) and these results showed that the lowest prevalence of any headache type in females experiencing TMD was chronic headache.

Table 4.21 Prevalence of chronic headache in females with TMD

Variable for total number of cases	TMD
Variable for number of positive cases	Females with chronic headache

Study	Sample size	Proportion (%)	95% CI	Weight (%)	
				Fixed	Random
Anderson 2011	345	16.52	12.76 to 20.87	89.64	69.09
Di Paolo 2009	39	7.69	1.61 to 20.87	10.36	30.91
Total (random effects)	384	13.94	7.30 to 22.28	100.00	100.00
Q	2.07				
DF	1				
Significance level	P = 0.14				
I^2 (heterogeneity)	51.83%				
95% CI for I^2	0.00 to 87.88				

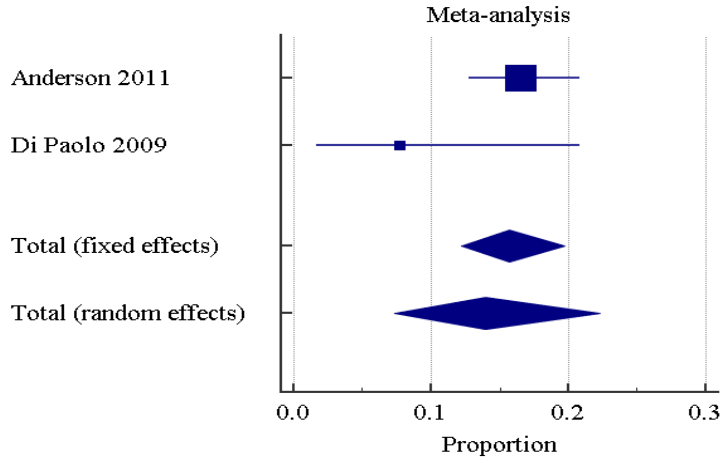

Figure 4.21 Forest plot showing the prevalence of chronic headache in females with TMD

4.4.5 Narrative description of studies

a) Prevalence of TMD in people experiencing concurrent migraine and tension-type headache

Only one study measured the prevalence of TMD in people who experienced migraine and tension-type headache simultaneously and could not be included in the meta-analysis due to insufficient data to be pooled (Ballegaard et al., 2008). The male and female prevalence could not be calculated as male and female prevalence was given for headache and TMD separately but not measurable for when they occurred concurrently. In this study, 15 out of 20 people with concurrent migraine and tension-type headache had TMD, with the total prevalence of TMD therefore measured at 75% (Ballegaard et al., 2008). This showed a significant correlation between concurrent migraine and tension-type headache and TMD. This prevalence of TMD was much higher than when migraine or tension-type headache occurred individually (Table 4.5) (Table 4.6). This high prevalence of TMD in this headache group showed that TMD was implicated in the generation of concurrent migraine and tension-type headache, and was a notable causative agent in this headache type, particularly in females.

b) Prevalence of concurrent migraine and tension-type headache in people experiencing TMD

One study examined the prevalence of concurrent migraine and tension-type headache in people who had TMD and could not be included in the meta-analysis (Di Paolo et al., 2009). This study had a total of 45 participants, all with TMD. Of these participants, 68.9% had migraine and concurrent tension-type headache (Di Paolo et al., 2009). The prevalence of concurrent migraine and tension-type headache in females with TMD was 71.8% (28 out of 39 females) and 50% for males (three out of six males). There was a significantly larger prevalence found in females than in males. This could also be explained by the large female representation in this study (86.7%) (Di Paolo et al., 2009). These results showed that the high prevalence of concurrent migraine and tension-type headache in individuals with TMD could be a likely cause of the TMD. It is apparent that concurrent migraine and tension-type headache have a bi-directional relationship, and the presence of one comorbidity increases the likelihood of the other.

Table 4.22 Standardised data extraction tool from the Joanna Briggs Institute Meta-Analysis of Statistics Assessment and Review Instrument (JBI-MAStARI)

Authors	Study type/ design	Location of study	Aims/Purpose of study	Participants	Outcome measures	Results	Conclusions
Anderson et al (2011)	A case-control study.	Multiple out-patient dental clinics in USA.	Determine the prevalence of headache in people with TMD.	604 people with TMD, 91 controls, 277 females with TMD, 32 males with TMD, mean age 37.3.	Headache: classified by ICHD-II. TMD: Questionnaires based on RDC/TMD axis I and II and clinical examination.	TMD: n=604 headache: n=309 TTH n=244 females with TTH n=219 males with TTH n=25 females with chronic headache n=58 males with chronic headache n=7	TMD and headache more prevalent in women, myogenous TMD most common type of TMD.
Ballegaard et al (2008)	Cross-sectional.	Danish Headache Centre (DHC) at Glostrup Hospital	Ascertain the prevalence of TMD in people with headache.	99 patients (76 female, 23 male), mean age of 44.8 years) age range 18-88 years old), all with headache.	Headache: ICHD-II measured by neurologists and diary recordings. TMD: RCD/TMD I and II	Headache n=46 TMD n=28 Migraine +TMD n=8 TTH + TMD n=5 Migraine + TTH n=15	Highest prevalence of TMD in patients with concurrent migraine and tension-type headache, followed by TTH.

Authors	Study type/ design	Location of study	Aims/Purpose of study	Participants	Outcome measures	Results	Conclusions
Ciancaglini and Radelli (2001)	Cross-sectional study (population sample).	Individuals chosen randomly from the town's census list in the municipality of Segrate in Northern Italy.	Determine the prevalence of headache in people with TMD.	A total of 483 personal interviews (carried out by dentists) were completed (300 females and 183 males; mean age 44.9 years)	Headache: ICHD-2 TMD: questionnaire, diagnosis per AAOP	TMD n=266 Headache n=73	Headache more prevalent in the sample with TMD than those without TMD, especially in females 50-60 years old.
Dahan et al (2016)	A cross-sectional, multicentre study.	Division of Dentistry at Montreal General Hospital, and the Orofacial Pain Clinic at Massachusetts General Hospital.	Determine the prevalence of headache in people with TMD.	The sample included 180 participants, including 121 in the myofascial-TMD group and 59 in the non-myogenous TMD group, the mean age of all participants was 42.8 ± 1.2 years, 82.8% of participants were female.	Headache: The ID-Migraine questionnaire, diagnosis according to ICHD-2. TMD: questionnaire, diagnosed according to the research diagnostic criteria for TMD (RDC/TMD).	TMD n=180 Migraine n=83	Migraine is more prevalent in people with myogenous TMD than those with non-myogenous TMD.

Authors	Study type/ design	Location of study	Aims/Purpose of study	Participants	Outcome measures	Results	Conclusions
Di Paolo et al (2009)	Cross-sectional study	The dental clinic school of dentistry of "Sapienza" University of Rome.	Determine the prevalence of headache in people with TMD.	A total of 45 patients (female/male: 39/6; mean age 34 ± 11), aged between 18-55, with TMD and craniofacial pain were consecutively recruited.	Headache: ID migraine questionnaire and Migraine Disability Assessment Scale (MIDAS), examination by a neurologist and diagnosis was based according to ICHD-II. TMD: Diagnosis based on RCD/TMD axis I.	TMD n=45 Migraine n=9 Chronic headache n=4 Migraine + TTH n= 31	This study showed a high prevalence of TMD with headache, especially in females (87%).
Fragoso et al (2010)	A prospective, cross-sectional study.	A Headache Outpatient Service in Brazil.	Ascertain the prevalence of TMD in people with headache.	The group consisted of 70 females and 10 males, with an average age of 47 years (±16.2). New patients, aged 18 or over. All the patients had had over one year of headaches.	Headache: clinical examination by a neurologist. Diagnosis per ICHD-II, analysed by second neurologist. TMD: AAOP	Headache n=80 TMD and migraine n=11 TMD and migraine without aura n=7 TMD and chronic headache n=5 TMD and cervicogenic headache n=1	As most of the sample were women, this study shows a higher prevalence of TMD and headache in women than in men, with migraine being the most prevalent

Authors	Study type/ design	Location of study	Aims/Purpose of study	Participants	Outcome measures	Results	Conclusions
							headache type.
Franco et al (2010)	A case-control study.	Orofacial Pain Clinic at Araraquara Dental School	Determine the prevalence of headache in people with TMD.	The sample consisted of 158 individuals with TMD and 68 without TMD (controls). Of those with TMD, 133 were women and 25 were men; mean age was 40.1 and 41.7respectively.	Headache: ICHD-II Based Questionnaire. TMD: RDC/TMD questionnaires administered to the patients as well as a clinical assessment by a dentist.	TMD n=158 Headache n=135 Migraine n=87 TTH n=48	Migraine is the most prevalent headache experienced in people with TMD with TTH being the next most common.
Goncalves et al (2010)	Population-based cross-sectional study by way of telephonic survey.	A stratified sample of 1230 habitants, from an urban area of in Brazil.	Determine the prevalence of headache in people with TMD.	1148 participants, women and men (proportion 51.5% and 48.5% respectively), aged 15-65 years old.	Headache: questionnaire, diagnosis per ICHD-2 TMD: A questionnaire, diagnosis per RDC/TMD	TMD n=725 migraine n=268 Chronic headache n=34 TTH n=141	Non-painful TMD symptoms showed a high prevalence of episodic tension-type headache.

Authors	Study type/ design	Location of study	Aims/Purpose of study	Participants	Outcome measures	Results	Conclusions
Goncalves et al (2013)	Case-control study.	University-based headache outpatient clinic	Ascertain the prevalence of TMD in people with headache.	61 females, 38 women with migraine, 23 with chronic migraine and 30 women without any type of headache over the past three months, aged between 20-55 years old.	Headache: Headache diagnosed by a neurologist according to ICHD–II. TMD: RDC/TMD, involving a 30-minute assessment, by a physiotherapist blind to the headache status.	Headache n=61 migraine and TMD n=21 chronic headache and TMD n=33	Only women were included in this study so did not give a reflection of population prevalence.
Mitrirattanakul and Merrill (2006)	Cross-sectional study.	The University of California, Los Angeles School of Dentistry.	Determine the prevalence of headache in people with TMD.	337 patients with orofacial pain and 367 general dentistry (control) patients were included in this study. Of patients with orofacial pain, the mean age was 47.02 years, 81.3% were female and 18.6% men.	Headache: MIDAS questionnaire, diagnosis according to ICHD-II TMD: diagnoses according to the American Academy of Orofacial Pain (AAOP).	TMD n=337 Migraine n=246 female TMD + migraine n=200 male TMD + migraine n=46	Headaches were much more prevalent in the orofacial pain group than the general dentistry group (control).

Authors	Study type/ design	Location of study	Aims/Purpose of study	Participants	Outcome measures	Results	Conclusions
Plesh et al (2011)	Cross-sectional study.	United States of America national Health Interview Survey (NHiS) data.	Determine the prevalence of headache in people with TMD.	The analyses included 8964 adults, over 18-years-old, 48% were males, 52% females.	Headache: questionnaire, diagnosis per ICHD-II TMD: questionnaire, diagnosis per RDC/TMD.	TMD n=8964 Migraine n=4706 female + migraine n=2447 male + migraine n=2259	Females with TMD had more headaches than those without TMD and more than males.
Silva Jr et al (2014)	Cross-sectional study	The Headache Specialty Centre (Belo Horizonte, Brazil), and Odontologic Training and Specializing Centre (Belo Horizonte, Brazil).	Determine the prevalence of headache in people with TMD.	289 headache patients, 78 TMD patients. The mean age was 42.7 years old for headache patients and 37.1 years for TMD patients. 86.9% of the headache group were women and 75.6% of the TMD group were women.	Headache: assessed by neurologists, diagnosis per ICHD-II TMD: TMD was assessed using the RDC/ TMD (axis I and II) and physical examination by dentists and physiotherapists.	Headache n=289 TMD n=194 TMD n=78 Migraine n=20 TTH n=36 Chronic headache n=3	Migraine was the most prevalent headache type in people with TMD. Myogenous TMD was more prevalent in people with headache.

Authors	Study type/ design	Location of study	Aims/Purpose of study	Participants	Outcome measures	Results	Conclusions
Tomaz-Morais et al (2015)	Cross-sectional study	Neurology out-patient centre of a tertiary clinic, Brazil.	Ascertain the prevalence of TMD in people with headache.	42 patients, 59.5% male (25 males), 17 females (40.5%). Mean age of 31 years (20-48), 21 with tension-type headache and 21 with migraine.	Headache: ICHD-II by way of interview TMD: RDC/TMD by way of questionnaire.	Headache n=42 Migraine + TMD n=15 migraine without aura + TMD n=14 TTH + TMD n=8	TMD was more prevalent in migraine than those with TTH. TMD was more prevalent in migraine without aura than with aura.
Von Piekartz and Ludtke (2011)	Randomized control trial.	Private practice physiotherapy out-patient centre in the Netherlands.	Ascertain the prevalence of TMD in people with headache.	43 patients with cervicogenic headache (27 women and 16 men, age range 18-65 years: average age 36+7.7 years)	Headache: patients diagnosed with cervicogenic headache by a neurologist according to IHCD-II TMD: Diagnosed according to RDC/TMD.	Cervicogenic headache n=43 TMD n=19	This study showed a higher prevalence in women than in men as the study had more female participants.

4.5 Summary of results

4.5.1 Summary of the prevalence of TMD in individuals experiencing headache

Table 4.23 Summary of prevalence of TMD in individuals experiencing headache

Headache type and TMD	Female prevalence	Male prevalence	Total prevalence
All headache types and TMD	60.11%	55.33%	59.28%
Migraine and TMD	-	-	63.28%
Tension-type headache and TMD	-	-	41.43%
Migraine and tension-type headache and TMD	-	-	75.0%
Migraine without aura and TMD	-	-	55.56%
Cervicogenic headache and TMD	-	-	44.67%
Chronic headache and TMD	-	-	64.16%

Dash (-) indicates that no meta-analysis was possible

4.5.2 Summary of the prevalence of headache in individuals experiencing TMD

Table 4.24 Summary of prevalence of headache in individuals experiencing TMD

Headache type and TMD	Female prevalence	Male prevalence	Total prevalence
All headache types and TMD	71.17%	61.98%	63.84%
Migraine and TMD	44.48%	50.34%	41.98%
Tension-type headache and TMD	37.73%	45.04%	30.13%
Migraine and tension-type headache and TMD	71.8%	50%	68.9%
Chronic headache and TMD	13.95%	17.15%	8.85%

Dash (-) indicates that no meta-analysis was possible

4.6 Conclusion of results

In conclusion, TMD was shown to present within all the headache groups measured. Females who experienced headache exhibited a higher prevalence of TMD in comparison to males. Individuals experiencing concurrent migraine and tension-type headache were most prone to having TMD and those with tension-type headache on its own were least likely to experience TMD concurrently.

After concurrent migraine and tension-type headache, people experiencing chronic headache had the highest prevalence of TMD. The male and female prevalence of headache sub-group analysis was not measured due to lack of prevalence data in the included studies. Concurrent migraine and tension-type headache was the most prevalent headache type experienced by individuals with TMD.

In females with TMD, concurrent migraine and tension-type headache was the most prevalent headache type experienced and migraine was the most prevalent headache type in males who had TMD. Individuals experiencing TMD were least likely to have chronic headache. The pooled prevalence of all headache types was higher in females with TMD than in males but males with TMD experienced more headaches than females in the individual headache-subgroups.

The prevalence of any headache occurring in people who had TMD was slightly higher than the prevalence of TMD occurring in people who had headache. This showed that individuals who had TMD were slightly more likely to experience headache compared to people who had headache experiencing TMD.

Chapter 5. Discussion

5.1 Introduction

The reciprocal relationship between TMD and headaches has been well established, and their prevalence as separate entities and entwined conditions have also been investigated and described in individual studies (Bernstein et al., 2013; Kraus, 2007; Speciali and Dach, 2015; Troeltzsch et al., 2011). In this systematic review, the aim was to seek out a global prevalence of TMD occurring within various headache types and the prevalence of headache in people experiencing TMD within the adult population. Headache types of interest in this review included migraine, migraine without aura, tension-type headache, cervicogenic headache and chronic headache. TMD was simultaneously present within these specified headache populations and their combined prevalence was determined.

The prevalence of TMD within all headache types was pooled to get a global prevalence as was the prevalence of headache types present in people with TMD. Individual headache sub-groups with concurrent TMD were measured and prevalence for each headache type with TMD attained too. Where possible, male and female prevalence of TMD within each headache group was measured, as was male and female prevalence of headache occurring in people who had TMD. All headache and TMD diagnoses were classified according to the International Classification of Headache Disorders (ICHD) (IHS, 2013), the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) and the American Academy of Orofacial Pain (AAOP) (Schiffman et al., 2014).

5.2 Quality of studies included in this review

The overall quality of studies in this systematic review was good (Table 4.1). The methodology of most studies and participant sampling procedure was well described, bar one study which was vague with regard to the participant recruitment for the study (Anderson et al., 2011). Most of the studies had large enough sample sizes except for three studies, which had a sample size of 45 or fewer participants (Di Paolo et al., 2009; Piekartz and Lüdtke, 2011; Tomaz-Morais et al., 2015). Despite the seemingly small number of participants, sample size calculations to estimate an adequate sample size required for the studies were performed. All studies showed

good statistical analysis and most studies presented sufficient data with results that were easy to interpret. For headache sub-group analysis, male and female prevalence was not possible to be measured in the studies that measured the prevalence of TMD occurring in people who had headache, but was possible to measure in most of the studies that examined the prevalence of headache occurring in people who had TMD. Most of the studies specified headache types in their research, which made sub-group analysis possible, except for one, which did not specify headache type (Mitrirattanakul and Merrill, 2006). The critical appraisal scores for each study can be seen in Table 4.1.

5.3 Prevalence of all headache and TMD

After meta-analysis of 14 studies, a global prevalence of TMD occurring within people experiencing any concurrent headache was measured at 59.28%. The highest prevalence of TMD occurring in both males and females who had headache was measured to be 67.12% (Silva Jr et al., 2014). In the reverse relationship, the prevalence of any headache type occurring in individuals who had TMD was 63.84%. This higher prevalence of headache occurring in people with TMD shows a strong association of TMD being a direct causative agent in headache generation. People who have TMD appear to be slightly more susceptible to experiencing headache compared to individuals with headache experiencing TMD. The high prevalence of TMD occurring in people with headache, and the higher prevalence of headache occurring in people who have TMD, show that both headache and TMD have a distinct cause and effect relationship.

The mean age of all the participants was 41.45 years. This is congruent with the literature, which has shown the most common age for headache and TMD symptoms to occur concurrently is between 35 and 50 years old (Gonçalves et al., 2010; Rantala et al., 2003; Yekkalam and Wänman, 2014). Both TMD and headache are more commonly seen in premenopausal women, with a direct link attributed to the female hormonal system (Ferreira et al., 2016). The menstrual cycle affects women's pain threshold and sensitivity, explaining why women between 20 and 50 years of age experience the most symptoms of headache and TMD (Ciancaglini and Radaelli, 2001; Ferreira et al., 2016; Franco et al., 2010). Tension-type headache and migraine both have a peak prevalence of 30 to 40 years of age, more commonly in women (Benoliel and Eliav, 2013; Freitag, 2006; Jensen and Stovner, 2008) but

interestingly, the risk of TMD increases with age (Kraus, 2014) whereas female prevalence of migraine decreases after the age of 50 years (Jensen and Stovner, 2008), again showing its relation to the female hormonal system.

Females had a higher prevalence of TMD when experiencing headache (60.11%) and an even higher prevalence of headache occurring when experiencing TMD (71.17%) as compared to males (55.33% and 61.98% respectively). The highest prevalence of TMD found in females who had headache was 88.52%, recorded by a study that solely included female participants with headache (migraine) and symptoms of TMD (Gonçalves et al., 2013), while the highest prevalence of TMD in males with headache was measured at 77.77% (Ballegaard et al., 2008). The highest prevalence of headache found in women with TMD was 97.43% (Di Paolo et al., 2009), which was significantly more than the highest male prevalence of 83.33% (Di Paolo et al., 2009). The higher prevalence seen in females can be explained by the difference in gender interpretation of pain and pain response (Franco et al., 2010; Karli et al., 2012; Sarlani et al., 2004).

One of the mechanisms explaining why women experience more pain than men, is related to hormonal control within females (Ferreira et al., 2016; Karli et al., 2012). The hormones oestrogen and progesterone have been shown to play a pivotal role in central and peripheral pain transmission in women (Karli et al., 2012). This results in women experiencing pain more intensely and more frequently than men and characterising their pain more severely than men do (Karli et al., 2012; Melo et al., 2012). In addition, women also tend to describe their pain as more continuous than men do as well as seek help for pain conditions more readily than men do (Franco et al., 2010; Karli et al., 2012; Melo et al., 2012). Women's propensity to seek treatment for their pain symptoms could explain why females represent a larger proportion of participants in the studies conducted in specialised tertiary centres (Franco et al., 2010).

Another explanation for the gender difference in pain symptoms was demonstrated by a study that examined the temporal summation of pain (repeated pain stimuli applied in intervals of constant intensity), and showed a distinct difference in how men and women interpret pain (Sarlani et al., 2007). Women reported higher pain responses to a mechanically induced pain stimulus than men did, concluding an upregulation of central nociceptive pain processing and thereby more noticeable pain sensation interpreted by women (Sarlani et al., 2007). A chronic pain syndrome such as TMD does not even have to be present for women to elicit a higher pain

response with repeated pain stimuli applied to an unrelated area of the body (Sarlani et al., 2004).

The high prevalence of TMD in women experiencing headache and the reverse relationship can be further explained by the central nervous system upregulation that occurs with TMD (Sarlani et al., 2007). Even when no distinct anatomical pathology can be found in the jaw and orofacial musculature of those with TMD, pain is a commonly reported symptom (Franco et al., 2010; Sarlani et al., 2007; Sarlani et al., 2004). This could also explain the substantially higher number of female participants seen in almost all the studies included in this systematic review.

In most of the studies included in this systematic review, myogenous TMD was shown to be the predominant type of TMD experienced, and people with myogenous TMD had a much stronger correlation with headache than with arthrogenous TMD (Ballegaard et al., 2008; Dahan et al., 2016; Di Paolo et al., 2009; Franco et al., 2010). One of the dominant characteristics of myogenous TMD is muscle spasm in the masticatory muscles, and this has been shown to be closely connected to, and responsible for, headache generation (Franco et al., 2010; Troeltzsch et al., 2011).

The continual stimulation of the trigeminal nucleus by TMD from nociceptive pathway changes due to increased muscle tone and activity of pericranial and masticatory musculature can influence the frequency and severity of primary headaches, and can be a triggering factor in people experiencing headache (Franco et al., 2010; Gonçalves et al., 2010). The predominance of myogenous TMD seen in the participants of these studies could explain why headache was so prevalent in people experiencing TMD (Franco et al., 2010; Gonçalves et al., 2010).

Headache and TMD are common comorbidities of each other and a distinct inter-relationship exists between them, making it difficult to identify which condition causes the other (Bernstein et al., 2013; Dahan et al., 2016). The high prevalence of headache seen in people who had TMD seen in the results, shows that headache can be linked to the onset of TMD symptoms. This can be explained by the central sensitisation that occurs from primary headache. The lack of inhibition of the trigeminal nucleus has been hypothesised to cause an increase in pericranial and masticatory muscle tone, triggering muscle spasm of these muscles and orofacial pain (Franco et al., 2010; Gonçalves et al., 2010). This disinhibition of the peripheral nociceptive pathways then triggers TMD, particularly, myogenous TMD (Franco et al., 2010).

5.4 Prevalence of concurrent migraine and tension-type headache and TMD

The highest prevalence of any headache type and TMD occurring simultaneously was when migraine and tension-type headache were experienced concurrently. The total prevalence of TMD found in people with concurrent migraine and tension-type headache was 75% (Ballegaard et al., 2008). Although male and female prevalence was not extracted from this study, women composed 90% of the sample group.

In individuals who had TMD, 68.9% had concurrent migraine and tension-type headache. The combination of migraine and tension-type headache was largely more prevalent in females with TMD as compared to males with TMD (71.8% and 50% respectively) (Table 4.24). These results show that females with TMD are much more likely to experience simultaneous migraine and tension-type headache than men are. Migraine and concurrent tension-type headache have been shown to increase the predisposition for TMD to occur (Ballegaard et al., 2008) and the extremely high prevalence found in this study confirms that.

Both studies measuring concurrent migraine and tension-type headache and TMD were conducted at specialised clinics: one for headache (Ballegaard et al., 2008) and the other a dental clinic (Di Paolo et al., 2009). Due to the nature of the clinical settings of these studies, an increased prevalence in both TMD and headache would be seen due to patients seeking help for either of these conditions (Di Paolo et al., 2009). Because women are more likely to seek help due to the increased frequency and perception of pain symptoms they experience, they tend to represent a larger proportion of patients seen at these clinics (Ballegaard et al., 2008; Franco et al., 2010). This can be seen in that women made up 87% to 90% of the participants in the studies examining the occurrence of concurrent migraine and tension-type headache and TMD. Although the high proportion of female participants could be seen to skew the results in favour of female prevalence, proportionately, females still displayed a higher prevalence of concurrent migraine and tension-type headache when experiencing TMD (Ballegaard et al., 2008; Di Paolo et al., 2009).

People with concurrent migraine and tension-type headache exhibited a far higher prevalence of TMD symptoms as compared to when migraine and TMD or tension-type headache and TMD occurred as single headache types (Table 4.23). When migraine and tension-type headache occurred together, there was a much higher likelihood of experiencing TMD symptoms, and in individuals with TMD, concurrent migraine and tension-type headache was

the most common headache type experienced (Ballegaard et al., 2008; Di Paolo et al., 2009; Troeltzsch et al., 2011).

The highly prevalent relationship between simultaneous migraine and tension-type headache and TMD, can be explained by each individual headache type's contributory role in TMD manifestation. Migraine has been shown to be causative agent in TMD generation from the lack of descending inhibition on neural pathways to the head and jaw as well as the neural overlap between the jaw and head (Graff-Radford, 2007; Troeltzsch et al., 2011). An increase in pericranial muscle tone and hyperactivity of the temporal muscles are noticeable features of tension-type headache, leading to increased muscle contraction of the jaw and facial muscles and TMD symptoms (Caspersen et al., 2013; Freitag, 2013). It was not unexpected that when these two headache types occurred simultaneously, the prevalence of TMD was increased, and there was an increased prevalence of theses headaches occurring simultaneously in people with TMD, as seen in these results.

5.5 Prevalence of migraine and TMD

After meta-analysis of the prevalence of TMD in both males and females experiencing migraine, the total prevalence was calculated at 63.28%. Conversely, the prevalence of migraine occurring in people who had TMD was 41.98% and was noticeably lower than the prevalence of TMD occurring in people experiencing migraine. The highest prevalence level of TMD occurring in men and women with migraine was 71.42% (Tomaz-Morais et al., 2015) and the highest prevalence of migraine occurring in men and women who had simultaneous TMD was 72.99% (Mitrirattanakul and Merrill, 2006). The high prevalence of TMD and migraine co-existing is expected due to the comorbid relationship between them (Speciali and Dach, 2015) and the occurrence of one of these conditions increases the likelihood of the other condition coexisting (Speciali and Dach, 2015).

The mean age of the group experiencing concurrent migraine and TMD was 40.5 years and is representative of the literature prevalence data, which shows that migraine most commonly occurs in people aged between 20 and 50 years old and peaks in the fourth decade (Gonçalves et al., 2013; Jensen and Stovner, 2008; Plesh et al., 2011), and TMD and headache occur together most frequently in people between the ages of 35 to 50 (Yekkalam and Wänman, 2014).

Although male and female prevalence could not be calculated from the studies measuring the prevalence of TMD in people experiencing migraine, females accounted for 73.3% of the participants with migraine. The large representation of females of reproductive age with migraine seen in these studies can be attributed to a neuroendocrine cause of pain in women (Karli et al., 2012; Silva Jr et al., 2014). After the onset of menarche, the female prevalence of migraine increases significantly as compared to males, again showing a hormonal link in the generation of migraine headache in women (Karli et al., 2012). Women experiencing migraine commonly report an onset or worsening of migraine symptoms during menstruation but only 4.4% are purely menstrual migraines (Karli et al., 2012). There is a sharp decline in migraine prevalence in women after the age of 50 years, and this runs in parallel with the menopausal age of women (Karli et al., 2012; Plesh et al., 2011; Yekkalam and Wänman, 2014). This again correlates with hormonal changes in females and the role they play in the generation of migraine symptoms in women, and explains the high prevalence of migraine and TMD of women of child-bearing age.

Despite the high number of female participants seen in these studies, the prevalence of migraine occurring in males with TMD was higher than in females (50.34% and 44.48% respectively). The number of male participants with TMD was consistently lower than that of females, yet showed a larger prevalence of migraine in most of the included studies. It is evident that studies which have higher female participant numbers usually report higher female prevalence, but can have skewed results due to more females included in studies than males. In one of the studies, the prevalence of migraine occurring in males and females with TMD was identical, despite that there were 57 female participants and only 19 male participants in the study. This shows that proportionately, males with TMD experience more migraine symptoms than females do, even though males are under-presented in the population of these studies.

An interesting point to consider in an epidemiological study on prevalence of TMD in people experiencing migraine is socioeconomic factors, which have been shown to have a definitive association with migraine prevalence (Le et al., 2011; Winter et al., 2012). People with low socioeconomic status have been shown to have an increased frequency of migraine symptoms. It is speculated that the link is driven by an increase in stress due to lack of education, poor financial circumstances, an unhealthy lifestyle and decreased access to healthcare for treatment of migraine (Le et al., 2011; Winter et al., 2012). Only two studies examining TMD and migraine prevalence in this systematic review considered socioeconomic status as a confounding factor in their studies (Dahan et al., 2016; Silva Jr et al., 2014). In these two

studies, years of education and employment status were mentioned, and migraine and TMD was more prevalent in those with lower levels of education and were unemployed (Dahan et al., 2016; Silva Jr et al., 2014).

5.6 Prevalence of migraine without aura and TMD

The total prevalence for TMD occurring simultaneously in people who had migraine without aura was 55.56%. Although less prevalent than in migraine, TMD was still a large contributor in the aetiology of migraine without aura. Two studies examined the prevalence of TMD in people who had migraine without aura, and this research specified migraine without aura as opposed to just migraine (Fragoso et al., 2010; Tomaz-Morais et al., 2015). From the results of the meta-analysis, migraine without aura was the fourth-most prevalent headache type experienced with concurrent TMD. However, the prevalence of migraine without aura could be under-represented in these studies as migraine without aura was often not specified, and it is the most common form of migraine (Benoliel and Eliav, 2013). Male and female prevalence of TMD in people experiencing migraine without aura could not be measured, but 64% of the participants experiencing migraine without aura were female.

An epidemiology study of migraine without aura has shown that women experience migraine without aura more frequently than males so it is fitting that there were more female participants than male presenting with migraine without aura (Jensen and Stovner, 2008). None of the included studies measured the prevalence of migraine without aura in people who were experiencing TMD.

5.7 Prevalence of tension-type headache and TMD

The analysis of two studies showed a total TMD prevalence of 41.43% in people experiencing tension-type headache and it has been estimated that tension-type headache has a global prevalence of 38%, and a 46% lifetime prevalence of occurring (Jensen and Stovner, 2008). In the reverse relationship, 30.13% of people who had TMD had concurrent tension-type headache. From these results, it appears that TMD contributes more to the creation of tension-type headache but that in reverse, tension-type headache has a lesser role in the generation of TMD.

Both tension-type headache and TMD have a cause-and-effect relationship with the pericranial and masticatory muscles, explaining why there is an almost indivisible affiliation between them (Caspersen et al., 2013; Freitag, 2006). In all the studies measuring the prevalence of tension-type headache in people who had TMD, myofascial TMD was the most prevalent type (Anderson et al., 2011; Di Paolo et al., 2009; Franco et al., 2010; Gonçalves et al., 2010; Silva Jr et al., 2014). This is due to the anatomical and neural interconnectivity of the head, face and jaw, eliciting muscle spasm of the pericranial and masticatory muscles from TMD and triggering tension-type headache (Anderson et al., 2011; Fumal and Schoenen, 2008).

The presence of TMD in people with tension-type headache was noticeably higher than tension-type headache being present in people who had TMD (41.43% and 30.13% respectively). From these results, one can infer that TMD triggers tension-type headache more than tension-type headache triggers TMD. The high prevalence of TMD in people who had concurrent tension-type headache found in this study can be explained by the fact that tension-type headache is strongly linked to teeth clenching, which in turn provokes tension-type headache symptoms (Anderson et al., 2011). The increased activity of the masticatory muscles has been shown to be partly responsible for the peripheral and central sensitisation that occurs with TMD and consequently tension-type headache generation (Anderson et al., 2011; Franco et al., 2010).

Females represented 58.6% of the participants in the two studies, and although male and female prevalence could not be measured, prevalence of both TMD and tension-type headache has been shown to be higher in females than males (Ciancaglini and Radaelli, 2001; Gonçalves et al., 2010; Jensen and Stovner, 2008; Silva Jr et al., 2014). However, the results of this review differ. In contrast, males who had TMD experienced a higher prevalence of tension-type headache compared to females (45.04% and 37.73% respectively). As expected, female participants largely outnumbered male participants by almost six-times yet the male prevalence was higher than the female. Perhaps from the results, one can hypothesise that males experienced larger amounts of myogenous TMD and subsequently experienced more tension-type headaches?

Interestingly, pain is not the only determinant symptom of the presence of TMD within people experiencing tension-type headache. TMD can be present without pain, but other symptoms of TMD such as limited mouth-opening, difficulty moving the jaw, crepitus in the TMJ and headache can be exhibited (Rantala et al., 2003). Goncalves et al (2010) found that 69% of the

sample with tension-type headache had pain-free TMD (Gonçalves et al., 2010). In this sample of 1148 people, most had myogenous type TMD yet pain was not the predominant feature of TMD within people experiencing tension-type headache (Gonçalves et al., 2010).

5.8 Prevalence of cervicogenic headache and TMD

Only two studies examined the prevalence of TMD in people with cervicogenic headache, and the results for total prevalence was 44.67%. Male and female prevalence could not be calculated but females made up most the participants at 75.1%. Women have been shown to have a higher prevalence of cervicogenic headache than men (Chou and Lenrow, 2002) and are more likely to seek help for their headaches than men, potentially explaining why there were much fewer male participants exhibiting cervicogenic headache in these studies (Fragoso et al., 2010; Franco et al., 2010; Piekartz and Lüdtke, 2011). Globally, prevalence of cervicogenic headache has been estimated at as low as 0.4% to 2.5% in some studies (Bernstein et al., 2013), and up to 13.8% to 35.4% of adults in other studies (Chou and Lenrow, 2002) but the results found in this systematic review show a higher prevalence when cervicogenic headache occurs concurrently with TMD.

This high association of TMD occurring in people experiencing cervicogenic headache can be explained by the close anatomical and neural overlap of the upper cervical spine and jaw (Chou and Lenrow, 2002; Piekartz and Lüdtke, 2011). Since cervical spine structures such as zygapophyseal joints, intervertebral discs and neck musculature have been implicated in the cause of cervicogenic headache as well as in the predisposition for TMD, it is expected that TMD and cervicogenic occur simultaneously (Kraus, 2014).

The pathogenesis of cervicogenic headache is commonly associated with dysfunction of the cervical spine structures and headache generated due to the neural convergence of the upper cervical spine nerves on the trigeminal nucleus (Chou and Lenrow, 2002; Piekartz and Lüdtke, 2011; von Piekartz and Hall, 2013). The cervical spine muscles and masticatory muscles have a synergistic relationship, and the muscles of mastication contract in accordance with the movement and contraction of the cervical spine musculature (Kraus, 2007). The spinal nerves of C1 to C2 converge on the trigeminocervical nucleus in the brainstem (Chou and Lenrow, 2002). This explains an increase in muscle spasm of the jaw muscles when there is an increase in cervical spine muscle contraction. The resultant increased activity in the orofacial muscles

stimulates the nociceptive pathways via the trigeminal neural pathways and elicit cervicogenic headache (Chou and Lenrow, 2002; Kraus, 2007).

One study exclusively examined the relationship between cervicogenic headache and TMD, and measured a total prevalence of 44.18% in people who had cervicogenic headache (Piekartz and Lüdtke, 2011). Mandibular deviation, limited mouth opening and increased sensitivity of the masseter and anterior temporalis muscles were commonly observed symptoms in people experiencing cervicogenic headache, showing the interrelationship between TMD and cervicogenic headache (Piekartz and Lüdtke, 2011). Patients exhibiting cervicogenic headache who received treatment of the temporomandibular joint and masticatory muscles, showed a significant improvement in the signs and symptoms of cervicogenic headache (Piekartz and Lüdtke, 2011; von Piekartz and Hall, 2013).

The entwined interconnection between cervicogenic headache and the associated high prevalence of TMD has been demonstrated by the fact that treatment of the cervical spine and orofacial structures in people experiencing cervicogenic headache led to a significant improvement of neck range of motion and pain, as well as reduction in headache symptoms (Piekartz and Lüdtke, 2011; von Piekartz and Hall, 2013). The improvement of cervicogenic headache with the treatment of the temporomandibular joint and its associated structures shows distinctly that TMD is a causative agent in the generation of this type of headache (Piekartz and Lüdtke, 2011; von Piekartz and Hall, 2013).

5.9 Prevalence of chronic Headache and TMD

Chronic headache is any headache type experienced on more than 15 days of the month on average for more than three months (IHS, 2013). The studies that reported chronic headache and TMD prevalence in this review measured chronic migraine and chronic tension-type headache. Three study results were pooled to give a total prevalence of 64.17% of TMD occurring simultaneously in people experiencing chronic headache.

The highest prevalence of TMD in people with chronic headache was 91.30% but this was a female-only study (Gonçalves et al., 2013). As previously discussed, females characterise their pain more severely and interpret pain more intensely than men and are sensitive to hormonal control when it comes to pain experience (Karli et al., 2012; Sarlani et al., 2007), and so the higher female prevalence is expected.

A substantial difference was seen in the prevalence of chronic headache in individuals who had TMD, with the total prevalence of chronic headache occurring in people who had TMD measured at only 8.85%. Of any headache type occurring in males with TMD, chronic headache was the least likely to occur, with the lowest prevalence in males recorded at 17.15%. The prevalence in females showed the same trend as males, with chronic headache-type showing the lowest prevalence measure of 13.95% in females who had TMD. Despite a substantially larger female participant number compared to males (384 and 56 respectively), males with TMD showed a higher prevalence of chronic headache than females. Although males with TMD displayed a higher predominance of chronic headache, chronic headache was not highly prevalent in both males and females who had TMD. Out of all the headache types, chronic headache had the weakest association with TMD. This is surprising since both migraine and tension-type headache have been shown to be strong comorbidities of TMD.

From the results of this study, it appears that when individuals experience chronic headache, there is a much higher prevalence of TMD occurring than in the reverse relationship. One can also deduce from these results that TMD is a large causative agent in the aetiology of chronic headache since TMD is seen so often in individuals with chronic headache. The reciprocal relationship however, is not seen, with a low prevalence of chronic headache occurring in individuals who had TMD, showing that the existence of chronic headache does not precipitate TMD. Of all the headache types measured in this study, it appears that chronic headache and TMD do not have a bi-directional relationship, with TMD chiefly instigating chronic headache, yet not the reverse.

5.10 Limitations of the studies

Most of the studies were conducted in specialised headache or dental outpatient clinics (12 studies). This could possibly allow for a higher prevalence measure of headache or TMD as loose-standing concepts since the patients visiting these clinics could be more likely to have headache or TMD than the broad population. Females dominated the participant proportion in most studies, and studies did not measure prevalence based on an equal number of male and female participants. Male and female prevalence of concurrent headache and TMD were not explicit in many studies and it was not possible to extract or measure this in many studies. Often prevalence of males and/or females with headache or TMD were given but not concurrently, so interpretation of these prevalence values was difficult and not possible in many

instances. Most of these studies measured prevalence at one point in time and the time frame can influence prevalence estimates. Studies measured over a length of time and not at one point would reflect a more accurate prevalence. Most of the studies examined migraine and TMD, and tension-type headache and TMD, and the fewest examined migraine without aura and TMD, and cervicogenic headache and TMD. Information on migraine without aura and TMD, and cervicogenic headache and TMD was less readily available.

5.11 Limitations of this systematic review

There were some limitations found when conducting this study. There was a very high level of heterogeneity measured when pooling all the studies together to get a total prevalence of TMD in individuals who were experiencing headache (Table 4.2), as well as very high level of heterogeneity measured from the pooling of all studies measuring the prevalence of headache in individuals who had TMD (Table 4.10). The study designs were different and included cross-sectional studies, case-controls and a randomised control trial (Table 4.22). This difference in study methodology added to the high heterogeneity seen in the results. The studies included did not have equivalent numbers of male and female participants, and the high representation of female participants could have potentially skewed the prevalence seen in females. Only two studies had relatively equal male and female participants and measured similar prevalence results for males and females (Gonçalves et al., 2010; Plesh et al., 2011).

Most of the studies measuring the prevalence of TMD in people experiencing headache did not present their results in a manner that allowed for clear and easy extraction of male and female prevalence values. Because of the lack of clarity of these prevalence values, male and female prevalence could not be accurately measured and had to be excluded from the results. Only three studies were population-based studies (Ciancaglini and Radaelli, 2001; Gonçalves et al., 2010; Plesh et al., 2011). The rest of the studies were conducted in specialised headache, neurology, physiotherapy or dental outpatient clinics (Table 4.22). The studies conducted in specialised clinics could have measured higher prevalence due to the nature of individuals specifically seeking help for TMD and headache symptoms at these clinics. Finally, some studies did not specify headache type, and therefore could not be included in the specific headache sub-groups (Ciancaglini and Radaelli, 2001; Silva Jr et al., 2014).

5.12 Conclusion of discussion

The results of this study show a significant prevalence of TMD occurring in people who had headache, as well as a substantial prevalence of headache occurring in people who experienced TMD. Females with headache exhibited a higher prevalence total prevalence of TMD than males, and headache was more likely to occur in females experiencing TMD than males. The highest prevalence of TMD occurring in any headache group was when migraine and tension-type headache presented simultaneously. The highest prevalence of headache occurring in females with TMD was concurrent migraine and tension-type headache, and the lowest prevalence was chronic headache. In males with TMD, the most prevalent headache type was migraine.

The headache type most frequently occurring in people with TMD was concurrent migraine and tension-type headache, and the least predominant headache type to occur in people who were experiencing TMD was chronic headache. Women with TMD showed a higher prevalence of experiencing headache than men, except migraine, tension-type headache and chronic headache, which were more prevalent in males with TMD. Myogenous TMD was the most prevailing type of TMD experienced within these headache populations.

TMD is a prevalent comorbidity of headache, and the occurrence of headache in people experiencing TMD was a prominent finding. Concurrent migraine and tension-type headache had the strongest association with TMD, with both being strong comorbidities of each other. TMD was least likely to be associated with, and caused by, chronic headache. The integral relationship between TMD and headache has been clearly demonstrated in this systematic review and the occurrence of one of these conditions increases the likelihood of the other occurring concurrently.

Chapter 6. Conclusion of systematic review

6.1 Conclusion

This systematic review aimed to determine the prevalence of the concurrent presence of TMD and headache. The first objective was to determine the prevalence of TMD occurring concurrently with people with headache and a second objective was to determine the prevalence of headache occurring in people who had TMD. This systematic review also sought to determine the prevalence of TMD in people with headache and the reciprocal relationship within various headache sub-groups as well as to determine male and female prevalence where possible.

After conducting a meta-analysis of 14 studies conducted in seven countries and including 12 130 participants, a global prevalence of TMD occurring simultaneously in people who headache was calculated at 59.28%. The total prevalence of TMD in women experiencing headache was 60.11% and for men, was 55.33%. The global prevalence of headache occurring concurrently in people who had TMD was 63.84%. Females with TMD had a higher prevalence of headache occurring simultaneously than men, with a female prevalence of 71.17% and a male prevalence of 61.98%. The average age group of all the participants was 41.45 years.

The most prevalent headache sub-group to have comorbid TMD symptoms, was when migraine and tension-type headache occurred concurrently (75%). TMD was most prevalent in women experiencing migraine (90.16%), followed by migraine and tension-type headache presenting simultaneously in women who had TMD (71.8%) while men who had TMD had the highest prevalence of migraine symptoms (50.34%). Men who had chronic headache were the least likely to have TMD occurring concomitantly. Coexisting migraine and tension-type occurring simultaneously with TMD were the highest comorbidities for each other.

People who had TMD were slightly more likely to experience headache as compared to people who experienced headache having TMD occurring simultaneously. However, prevalence of headache and TMD occurring concurrently was highly prevalent in both groups.

The results of this review show an inextricable relationship between headache and TMD prevalence, confirming their bi-directional relationship. As they are such strong comorbidities of each other, experiencing one of these conditions can allow a strong assumption that the other condition exists simultaneously too.

6.2 Implications for practice

Due to the significantly high prevalence of TMD within people experiencing headache and the reciprocal relationship, it would be strongly recommended to assess the temporomandibular joint and associated muscular structures of patients presenting with headache. Due to the frequency of these two conditions occurring together, a comprehensive evaluation of headache type, and diagnosis according to the International Classification of Headache Disorders- beta version (ICHD-2) (IHS, 2013) is necessary. At the same time, TMD must be considered and diagnosis included or excluded by way of the Research Design Criteria for TMD (RDC/TMD) axis I and II criteria (Schiffman et al., 2014). If TMD is diagnosed when headache is present, or headache symptoms are present in people who have TMD, outcomes of headache and TMD treatment could be greatly improved by physiotherapists and other practioners, if both conditions are treated accordingly and simultaneously.

6.3 Recommendation for future research

Cervicogenic headache and TMD is not an abundantly researched area and information on the prevalence of these combined conditions was difficult to attain. Studies done on prevalence of TMD and cervicogenic headache are scarce. It was difficult sourcing studies on cervicogenic headache and TMD together, and there is not sufficient epidemiological information on the prevalence of TMD in people experiencing cervicogenic headache. More prevalence studies are also required on migraine without aura and TMD. Most studies just focus on migraine or generalise migraine and don't specify 'without aura'. Migraine without aura is a prevalent headache type and these results showed a high prevalence of TMD occurring in people with migraine without aura. Although the prevalence was shown to be high from this review, there were only two studies which measured the prevalence of TMD in people experiencing migraine without aura and more studies on this condition are required. Some of the results in the studies were difficult to interpret and future studies with results clearly indicating prevalence and proportion for each headache type with TMD, as well as clear male and female prevalence of concurrent headache and TMD would make meta-analysis easier.

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Appendices

Appendix A: JBI Critical Appraisal Checklist for Studies Reporting Prevalence Data

Reviewer: Date:

Author: Year: Record number:

	Yes	No	Unclear	Not Applicable
1. Was the sample representative of the target population?				
2. Were study participants recruited in an appropriate way?				
3. Was the sample size adequate?				
4. Were the study subjects and the setting described in detail?				
5. Was the data analysis conducted with sufficient coverage of the identified sample?				
6. Were objective, standard criteria used for the measurement of the condition?				
7. Was the condition measured reliably?				
8. Was there appropriate statistical analysis?				
9. Are all important confounding factors/subgroups/differences identified and accounted for?				
10. Were subpopulations identified using objective criteria?				

Overall appraisal: Include ☐ Exclude ☐ Seek further info ☐

Appendix B: JBI Data Extraction Form for Prevalence and Incidence Studies

Study details Reviewer –

Study ID/Record Number –

Date –

Study title –

Author –

Year –

Journal –

Aims of the study –

Study Method Setting –

Study design –

Follow-up or study duration –

Subject characteristics –

Dependent variable –

Outcomes –

Outcome measurements –

Ethical approval –

Method of data analysis -

Results: Prevalence n/N (%) proportion and 95% confidence intervals

Authors' comments

Reviewer comments

Appendix C: Ethics waiver

Human Research Ethics Committee (Medical)

Research Office Secretariat: Senate House Room SH10005, 10th floor. Tel +27 (0)11-717-1252
Medical School Secretariat: P V Tobias Health Sciences Building, 2nd floor
Tel +27 (0)11-717-2700 / 1234 / 1252 / 2656
Private Bag 3, Wits 2050, www.wits.ac.za. Fax +27 (0)11-717-1265
South African National Health Research Ethics Council registration: REC-250208-04
United States Office of Human Research Protections registration: FWA00000715 IRB00001223

Ref: W-CJ-160420-1 20/04/2016

TO WHOM IT MAY CONCERN:

Waiver: This certifies that the following research does not require clearance from the Human Research Ethics Committee (Medical).

Investigator: **Jackie Mosselson (9904394W).**

Project title: **Prevalence of temporomandibular dysfunction in people experiencing headache: a systematic review.**

Reason: This study is a systematic review using information in the public domain. There are no human particpants.

UNIVERSITY OF THE WITWATERSRAND
PROF PE CLEATON-JONES
HREC (MEDICAL)
2016 -04- 20
JOHANNESBURG

Professor Peter Cleaton-Jones

Chair: Human Research Ethics Committee (Medical)

Copy – HREC (Medical) Secretariat: Zanele Ndlovu, Rhulani Mkansi.

Appendix D: Table for excluded studies

Authors/Study	Reason for exclusion
(Akhter et al., 2013)	The study focused on the presence of TMD symptoms and the presence of aural symptoms and vertigo and did not measure prevalence of combined headache and TMD.
(Caspersen et al., 2013)	This study examined the relationship between tension-type headache, TMD and sleep. The results measured TMD symptoms and headache and was unable to get a TMD and headache prevalence together.
(Da Silva Jr et al., 2010)	This study included children in the participants and therefore did not meet the inclusion criteria.
(da Silva Junior et al., 2013)	This study included children in the participants and therefore did not meet the inclusion criteria.
(Graff-Radford and Bassiur, 2014)	This study focused on the treatment of TMD to alleviate headache and did not measure prevalence of TMD with concurrent headache.
(Hara et al., 2016)	This study focused on headache attributed to TMD and was not one of the headache types specified in the inclusion criteria.
(Melo et al., 2012)	The results in this study measured signs and symptoms of TMD in people with headache but prevalence values were not able to be obtained from the data in this study.
(Ozkan and Ozkan, 2011)	This study provided insufficient data on headaches and mostly focused on TMD symptoms such as clicking, crepitus and muscle trigger points. Unable to work out prevalence of concurrent TMD and headache.
(Plesh et al., 2012)	This study examined the genetic influence on TMD and migraine in twins and didn't measure prevalence of TMD and migraine.
(Rantala et al., 2003)	Unable to establish the prevalence of TMD in people with headache or headache in people with TMD from the given data.
(Siqueira et al., 2015)	Unable to establish prevalence of headache and TMD together from the data provided and the study was comparing pain symptoms between two age groups and not prevalence.
(Speciali and Dach, 2015)	This study was a systematic review of headache and TMD but it didn't measure prevalence of the two occurring together.

Authors/Study	Reason for exclusion
(Troeltzsch et al., 2011)	Unable to determine the prevalence of headache occurring in TMD or TMD occurring in people with headache from the data provided.
(Ungari et al., 2012)	The study results focused on condylar lock, mandibular deviation and articular noises and the relation to headache. Unable to work out prevalence of concurrent TMD and headache from the data provided.
(Yekkalam and Wänman, 2014)	This study measured signs and symptoms of TMD across various age groups, and prevalence was not able to be measured precisely in the group which had combined symptoms of TMD and headache.

Appendix E: Plagiarism Declaration

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PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

l, Jackie Mosselson (Student number: 9904394W) am a student registered for the degree of Master in Physiotherapy in the academic year 2017.

I hereby declare the following:

-I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.

-I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
I have followed the required conventions in referencing the thoughts and ideas of others.

-I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.

-I have included as an appendix a report from "Turnitin" (or other approved plagiarism detection) software indicating the level of plagiarism in my research document.

Signature: J Mosselson Date: 28/03/2017

Appendix F: Turnitin Report

Document Viewer

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Research report final 3 By Jackie Mosselson

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http://www.joannabriggs.org/assets/docs/jbc/operations/criticalAppraisalForms/JBC_Form_CritAp_Prev.pdf

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Handbook of Headache, 2011.

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Xie, Tingting, Xiaobing Cui, Haoxuan Zheng, Dong Chen, Ling He, and Bo Jiang. "Meta-analysis : eradication of Helicobacter pylori infection is associated with the development of endoscopic gastroesophageal reflux disease", European Journal of Gastroenterology & Hepatology, 2013.

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http://joannabriggs.org/assets/docs/jbc/introductions/scientificCommittee/oct14/SciCom_all_Oct2014.pdf

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Ulrich, V.. "A comparison of tension-type headache in migraineurs and in non-migraineurs: a population-based study", Pain, 199610

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http://globallearningcentre.joannabriggs.edu.au/assets/docs/sumari/ReviewersManual_2014-The-Systematic-Review-of-Prevalence-and-Incidence-Data_v2.pdf

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http://wiredspace.wits.ac.za/jspui/bitstream/10539/9285/1/Research%20Report%20Final.pdf

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Ballegaard, V, P Thede-Schmidt-Hansen, P Svensson, and R Jensen. "Are headache and temporomandibular disorders related? A blinded study", Cephalalgia, 2008.

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Muscle Pain Diagnosis and Treatment, 2010.

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http://waswc.soil.gd.cn/books/Soils%20of%20EU%20081120%20(e-book,%204%20MB%20-%20hard%20copy%20also%20available%20for%20free).pdf

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BK Rasmussen. "Epidemiology of headache", Cephalalgia, 2/1995

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Michael Bjørn Russell. "Tension-type Headache in Adolescents and Adults: A Population Based Study of 33,764 Twins", European Journal of Epidemiology, 02/2006

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"The International Classification of Headache Disorders 2nd Edition", Cephalalgia, 5/2004

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I. Santos, F. F. Sniehotta, M. M. Marques, E. V. Carraça, P. J. Teixeira. "Prevalence of personal weight control attempts in adults: a systematic review