The relationship between range of motion of the temporomandibular joint and upper cervical spine in patients with cervical pain

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DECLARATION

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

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ABSTRACT

Background

An anatomical, biomechanical and neurophysiological relationship between the temporomandibular joint and upper cervical spine exists but an improvement in the treatment approaches of cervical pain is needed. The aim of the study was to determine if there is a relationship between the range of motion of the upper cervical spine and the range of motion of the temporomandibular joint in participants with neck pain.

Method

This observational study included 25 participants with neck pain and 25 with no pain. The group with neck pain completed the Numerical Rating Scale and the Neck Disability Index. The range of motion of upper cervical flexion and extension were analysed using Kinovea and the range of motion of mouth opening was determined using a ruler. Results were analysed using independent t tests and correlation coefficients.

Results

Non-significant relationships were found between the range of motion of the temporomandibular joint and range of motion of upper cervical flexion ($r = 0.27$) and upper cervical extension ($r = -0.026$) as well as between the intensity of cervical pain and the range of motion of the temporomandibular joint r (50) = 0.084 and between functional limitations of cervical pain and range of motion of the temporomandibular joint r (50) = 0.064. A significant relationship between neck pain intensity and functional limitations due to cervical pain r (50) = 0.88, p <.000 was found.

Conclusion

There is a significant relationship between neck pain intensity and disability in participants with neck pain and no significant relationship between the range of motion of upper cervical flexion and extension and mouth opening. Therefore, the inclusion of an assessment of the ROM of the TMJ in patients with cervical pain is not necessarily indicated.

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LIST OF ABBREVIATIONS

CMJAH- Charolette Maxeke Johannesburg Academic Hospital

DC/TMD- Diagnostic Criteria for Temporomandibular Disorders

NDI- Neck Disability Index

NRS- Numerical Rating Scale

ROM- Range of motion

RCT- Randomised controlled trial

TMD- Temporomandibular joint dysfunction

TMJ- Temporomandibular joint

VAS- Visual Analogue Scale

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CHAPTER 1- BACKGROUND AND NEED

1.1 Introduction

At any given time, 10-20% of the population has cervical pain and of this population, 22-70% will experience pain for a lifetime (Cleland, Childs and Whitman, 2008) and therefore neck pain is one of the most common musculoskeletal conditions and is ranked, together with back pain, as one of the leading causes of disability (Hoy, et al., 2014). In Sub-Saharan Africa, the prevalence of neck pain was found to be 4.7% in males and 6.7% in females with a higher rate of depression and anxiety amongst them (Basson, Olivier and Rushton, 2019; El-Sayed, et al., 2010). Globally, there is a higher prevalence of neck pain in women, higher income countries and urban areas. This high prevalence leads to high levels of compensation for neck pain, accounting for 18% of disability payouts in the United States (Cleland, Childs and Whitman, 2008).

In a study of 50 participants presenting with cervical pain, 90% of them were found to have temporomandibular joint dysfunction (TMD) (Ferão and Traebert, 2008). TMD is described as a group of disorders pertaining to pathology of the temporomandibular joint (TMJ) and or the masticatory muscles. It has been found that people with TMD commonly present with cervical pathology and those with cervical pain have a greater degree of TMD than those without cervical pain (Stiesch-Scholz, Fink, and Tschernitschek, 2003 and Packer, et al., 2014).

A survey of 4289 people found 50% of participants to have signs of TMD with only 10% of them reporting pain in the temporomandibular joint region (von Piekartz, et al., 2016). Causes of reduced range of motion (ROM) of the TMJ include joint stiffness, emotional stress, malocclusion, overuse of the masticatory muscles and external trauma. Decreased ROM of the TMJ can lead to crepitus and clicking in the joint, pain over the TMJ, tinnitus, cervicogenic headaches and referred pain to the cervical spine and shoulder region (Bae and Park, 2013 and Packer, et al., 2014).

There is a close biomechanical and anatomical relationship between the TMJ, atlanto-occipital and atlanto-axial joints. The close biomechanical relationship is shown in that there are simultaneous movements of the TMJ and the upper cervical spine- during mouth opening, there is upper cervical extension and during mouth closing there is upper cervical flexion (Eriksson, Zafar and Nordh, 1998). This was confirmed in a study by Mansilla-

Ferragut, et al. (2009) where there was a reduction in the ROM of the TMJ on mouth opening when the mobility of the upper cervical spine was reduced by stabilizing the head.

The TMJ and upper cervical joints (O1/C1 and C1/2) are proximally located. There is also a close anatomical relationship between the muscles of the TMJ and cervical region such as the sternocleidomastoid and suprahyoid muscles. For example, the sternocleidomastoid inserts onto the mastoid process of the skull and the posterior belly of digastric originates from the mastoid notch, medial to the mastoid process, and inserts onto the hyoid bone. Therefore, there is a myofascial connection between the muscles of the TMJ and cervical spine (Grondin, Hall, Laurentjoye and Ella, 2015). The trigemino-cervical nucleus is an area in the upper part of the spinal cord where the first three cervical nerve roots converge with sensory fibres of the trigeminal nerve. This convergence results in referred pain from the upper cervical spine to the areas of the face supplied by the trigeminal nerve and visa-versa (Mansilla-Ferragut, et al., 2009).

The positioning of the jaw and the upper cervical spine have also found to be interrelated (Greenbaum, Dvir, Reiter and Winocur, 2017). It has been found that people with TMD present with a forward head posture, with their upper cervical spine (C1 and C2) in hyperextension and their lower cervical spine (C3-C7) in flexion. This leads to reduced mobility of the upper vertebral joints and myofascial changes and shortening of cervical muscles especially the upper fibres of trapezius, semispinalis, splenii, the suboccipital and sternocleidomastoid muscles. This forward head posture has been found to be more prevalent in people with TMD compared to those without TMD (Packer, et al., 2014).

There is conflicting evidence in the literature regarding the ROM of the TMJ and upper cervical spine. One study (Greenbaum, Dvir, Reiter and Winocur, 2017) found a reduced overall ROM of the cervical spine in participants with TMD while another found no significant reduction (Grondin, Hall, Laurentjoye and Ella, 2015). In a study investigating the prevalence of TMD in participants with cervical pain, it was found that most of the participants reported no improved symptoms with regular cervical physiotherapy (Ferão and Traebert, 2008).

1.2 Problem statement

It is evident that there is a high prevalence of neck pain and disability resulting from the pain and therefore evidence to improve the treatment of neck pain is critical. There is conflicting evidence on the relationship between the ROM of the TMJ and upper cervical spine and if a relationship can be found, motivation to include treatment of the TMJ in patients with cervical pain will be achieved. There have been no previous research studies investigating whether there is a correlation between reduced ROM of the TMJ and upper cervical spine flexion and extension.

Another reason for the significance of this study is that physiotherapists commonly do no not include an assessment and treatment of the TMJ in cervical conditions. This is evident as in a neuromusculoskeletal postgraduate course run in South Africa, there is no inclusion of an assessment of the TMJ in the standard cervical evaluation component of the course (Rushton, et al., 2012).

1.3 Research question

Is there a relationship between the ROM of the TMJ and upper cervical spine in participants with cervical pain?

1.4 Aim of the study

To determine if there is a relationship between the ROM of the TMJ and the upper cervical spine in patients with cervical pain.

1.5 Objectives of the study

To determine:

- if there is a relationship between the ROM of upper cervical flexion and the TMJ on mouth opening.
- if there is a relationship between the ROM of upper cervical extension and the TMJ on mouth opening.
- if there is a relationship between the intensity of cervical pain and the ROM of the TMJ on mouth opening.

- if there is a relationship between the functional limitations (disability, reduction in quality of life, pain affecting sleep and work) due to cervical pain and the ROM of the TMJ on mouth opening.
- if there is a difference in the ROM of the TMJ and upper cervical spine between the group with cervical pain and without cervical pain.

1.6 Significance of the study

The findings of this study can inform physiotherapists whether the inclusion of assessing and treating the TMJ in patients with cervical pain is indicated. This may lead to improved outcomes of treatment and reduce the high prevalence of chronicity of cervical pain. The findings can also improve the treatment of TMD as there are manual therapy techniques that have been proven to improve upper cervical extension and flexion and therefore these techniques can be used in the treatment of TMD.

1.7 Organisation of the research report

The diagram below shows the steps followed for the research report

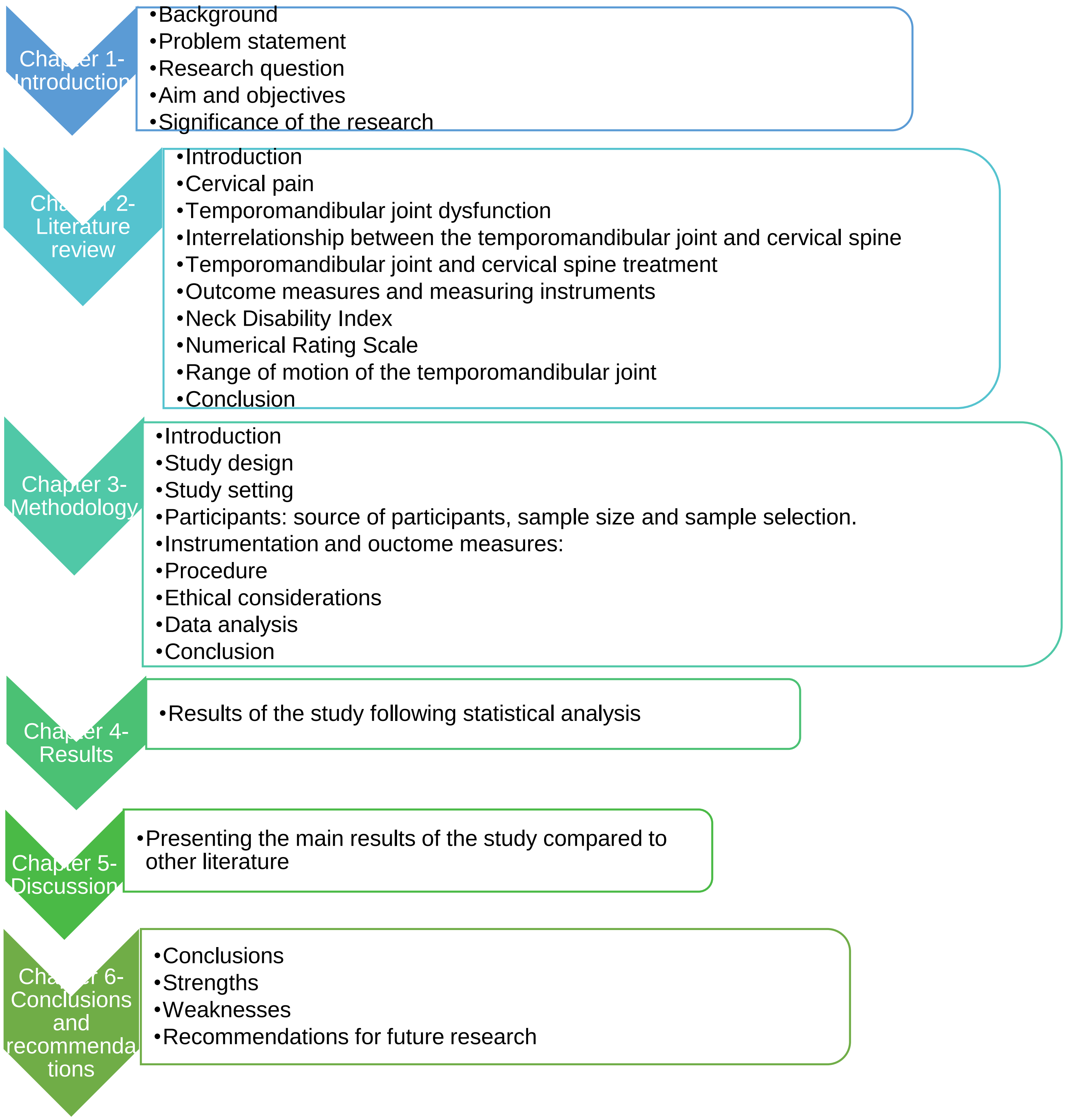

Figure 1-1: Organisation of the research report

CHAPTER 2- LITERATURE REVIEW

2.1 Introduction

In this chapter, the literature that supports the research question will be discussed. This literature review will begin by discussing cervical pain, TMD followed by the interrelationship between the TMJ and cervical spine as well as the effects of treating the TMJ in cervical spine conditions and the contrary. The tools used to measure the ROM of the TMJ and upper cervical flexion and extension, intensity of cervical pain as well the impact of neck pain on daily function will also be discussed.

Methodology

This review was compiled from the literature found on ScienceDirect, Scopus, PubMed and PEDro databases. The key words used to perform the search included cervical pain, temporomandibular dysfunction, upper cervical spine, temporomandibular joint and physiotherapy for cervical dysfunction. Studies from 2000-2020 were included in this literature review as there is limited research available. Hand searches of references were also conducted.

2.2 Cervical pain

Neck pain is described as a ‘pain in the neck with or without referred pain into one or both upper limbs’ (Basson, Olivier and Rushton, 2009, p.1). In a study done by Rasmussen-Barr, et al. (2014), only 36% of 1800 participants with neck pain had neck pain alone with the remainder of the participants having neck pain with radiating arm pain. This radiating pain has been found to have a negative influence on quality of life and disability (De Pauw, et al., 2015).

Neck pain has been found to be one of the most debilitating conditions across the world, placing an economic burden on the patient, their family and the economy (Hoy, et al., 2014) with a prevalence of 30-50%, a point prevalence of 4.7% and a lifetime prevalence of 14.2-70% depending on which country was measured (Hogg-Johnson, et al., 2009). It has been found that in South Africa, 53,7% of adolescents experience neck pain (Mafanya and

Rhoda, 2011) and 76% of office workers complaining of musculoskeletal conditions are of cervical origin (Basson, et al., 2017)

Neck pain has been classified into four grades namely:
Grade one- neck pain without signs of massive pathology and that does not interfere with the patient's daily routine.
Grade two- neck pain without signs of massive pathology but does interfere with the patient's daily routine.
Grade three- neck pain with signs of nerve compression.
Grade four- neck pain with signs of massive pathology (Guzman, et al., 2009).

It has been found that the major causes of neck pain are psychosocial rather than mechanical (Kim, et al., 2018). Sustained or awkward positions was the most common mechanical predisposing factor to neck pain but was a lower hazard compared to low mood, stressful jobs, low job satisfaction, an unpleasant work environment and sleep disturbances (Yang, et al., 2016; Rasmussen-Barr, et al., 2014; Kim, et al., 2018). Non modifiable factors that increase the risk of neck pain are the female gender and older age (Kim, et al., 2018).

Factors that worsen the prognosis of neck pain have been found to be high levels of pain at baseline (OR 5.61, 95%CI 3.74–8.43) and a score on the Neck Disability Index (NDI) at baseline of 15/50 or higher. There are three common patterns of recovery from neck pain, 19.6% of people with neck pain recover within a month, 65,8% of people have a longer recovery with a non-significant reduction in pain and disability within a month and 14,6% of this population have worsening of symptoms. This indicates that only 20% of the population with neck pain will recover well highlighting the poor prognosis of acute neck pain and the need to explore more options to treat this pain (Walton, Eilon-Avigdor, Wonderham and Wilk, 2014).

2.3 Temporomandibular joint dysfunction

Temporomandibular joint disorders are classified as a group of neuromuscular or musculoskeletal pathologies affecting the TMJ, muscles of mastication and/or surrounding structures (Olivo, et al., 2010). The Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) is a common tool used to diagnose TMD (Schiffman, et al., 2014). According to the DC/TMD, TMD can be classified into TMJ disorders, masticatory muscle disorders, headaches or associated structures. Joint disorders of the TMJ may be due to arthritis, disc dysfunction, hypomobility, hypermobility or joint diseases. Masticatory muscle disorders may be due to local myalgia or myofascial pain, tendinopathy, spasm, myositis, hypertrophy or fibromyalgia (Schiffman, et al., 2014).

Causes of reduced ROM of the TMJ include joint stiffness, emotional stress, malocclusion, overuse of the masticatory muscles and external trauma. Decreased ROM of the TMJ can lead to crepitus and clicking in the joint, pain over the TMJ, tinnitus, cervicogenic headaches and referred pain to the cervical spine and shoulder region (Bae and Park, 2013; Packer, et al., 2014). Symptoms of TMD are pain in the muscles of mastication, TMJ/s, periauricular area, referred facial or cervical pain (Calixtre, et al., 2016). Signs of TMD are noises in the joint, reduced range of mouth opening and limitation of orofacial functions such as eating and talking.

According to Bae and Park (2013), 65-80% of the population suffer from pain from the TMJ or reduced range of mouth opening. Temporomandibular joint disorders are a very common issue with it being ranked the second most common musculoskeletal complaint after back pain. It has been found that 8 out of 10 people will report symptoms of TMD or bruxism to their dentist (Shousha, Soliman and Behiry, 2018). TMD is more common in females, especially in the 45-60 years age group compared to males with a prevalence ratio of 4:1 (Bae and Park, 2013). It has also been found that women more commonly seek treatment with a ratio of 8:1 compared to males (Sharma, Pal, Gupta and Jurel, 2011). Temporomandibular joint dysfunction has been found to have a significant impact on the economy with the United States spending 4 billion dollars a year on managing patients with TMD.

Effective management of TMD consists of identifying and improving contributing factors such as bruxism, malocclusion, poor head posture, parafunctional habits (nail biting) and psychosocial factors such as emotional stress, anxiety and depression (Sharma, Pal, Gupta and Jurel, 2011).

2.4 The interrelationship between the temporomandibular joint and cervical spine

It has been found that 59% of people with TMD symptoms present with other pain with the most common pain being cervical (Adelizzi, et al., 2016). Even participants with TMD that had no complaints of cervical pain had reduced ROM of cervical extension, flexion, rotation and lateral flexion as well as changes in muscular patterns (Stiesch-Scholz, Fink and Tschernitschek, 2003; Olivo, et al., 2010). These include participants with TMD having a reduced endurance of the cervical extensor and flexor muscles with altered activity of the anterior scalene and sternocleidomastoid muscles when performing the Cranio-cervical Flexion Test (Calixtre, et al., 2016; Olivo, et al., 2010).

There are numerous links between the TMJ and cervical spine with one of them being neurophysiological. The trigemino-cervical nucleus is an area in the upper part of the spinal cord where the first 3 cervical nerve roots converge with sensory fibres of the trigeminal nerve. This convergence results in referred pain from the upper cervical spine to the areas of the face supplied by the trigeminal nerve and visa-versa (Mansilla-Ferragut, et al., 2009). This connection also results in reflexive activity in the cervical spine when the trigeminal nerve is activated (Eriksson, Zafar and Nordh, 1998).

There is a close biomechanical and anatomical relationship between the TMJ, atlanto-occipital and atlanto-axial joints. The TMJ and the upper cervical joints, O1/C1 and C1/2, are proximally located with a close relationship between the muscles of the TMJ and cervical region. The position of the jaw is influenced by the position of the upper cervical spine and the converse is also true. The ‘sliding cranium theory’ states that a forward head posture causes compression of the TMJ due to an increased load on the suprahyoid muscles (Greenbaum, Dvir, Reiter and Winocur, 2017). This forward head posture, more common in participants with neck pain, occurs due to weakness of the anterior neck muscles, tightening of the sternocleidomastoid, spasm of the suprahyoid and upper trapezius muscles which leads to a change in the position of the mandible. The change in position of the mandible causes an increased activity of the masticatory muscles and therefore increases the risk of TMD (Evcik and Aksoy, 2004). This position also leads to reduced mobility of the upper vertebral joints as the upper cervical spine (C1 and C2) is in hyperextension and the lower cervical spine (C3-C7) is in flexion (Packer, et al., 2014).

This is supported by the findings of a study by La Touche, et al. (2011) where the pain pressure threshold of the muscles of mastication and the ROM of mouth opening were measured with the head in a neutral head position, in retraction and in a forward head posture. The results showed that in the varying head positions, there were significant differences in maximal mouth opening and pain pressure thresholds of the masseter and temporalis muscles. The greatest maximal mouth opening was in the forward head posture position followed by the neutral position then the retracted position. The opposite was true for the pain pressure threshold which was found to be the highest in the retracted position, lower in the neutral position and the lowest in the forward head poke. The reason for these differences is due to the change in the resting position of the mandibular condyles in the varying head positions. It has been proposed that there is posterior positioning of the mandibular condyles during the forward head poke position, this is seen by an anterior translation of the mandibular condyles when the head moves towards a retracted position (La Touche, et al., 2011).

This is further supported and in agreement with the research that shows there are simultaneous movements of the TMJ and the upper cervical spine with head-neck extension occurring during mouth opening and head-neck flexion occurring during mouth closing (Eriksson, Zafar and Nordh, 1998). The simultaneous TMJ and cervical movements was also shown by a reduction in ROM of the TMJ on mouth opening when the head was externally stabilised (Mansilla-Ferragut, et al., 2009). There is also activation of neck muscles and the suprahyoid muscles on mouth opening compared to higher activity of the masseter muscle on mouth closing (Mansilla-Ferragut, et al., 2009).

The relationship of the ROM of the TMJ and cervical spine has been explored with Greenbaum, Dvir, Reiter and Winocur (2017) and Grondin, Hall, Laurentjoye and Ella (2015) finding a decreased ROM of C1/2 on the flexion rotation test in participants with TMD with and without headaches. Sagittal plane ROM was also found to be reduced in these participants but was not exclusively measured in the upper cervical spine (Grondin, Hall, Laurentjoye and Ella, 2015). However, Greenbaum, Dvir, Reiter and Winocur (2017) found no difference in ROM of active movements of the cervical spine in participants with and without TMD and noted a poor reliability of the results of the study done by Grondin, Hall, Laurentjoye and Ella (2005).

Overall, there is strong evidence supporting the relationships between the cervical spine and TMJ but specific evidence on the upper cervical spine is conflicting and inconclusive.

2.5 Temporomandibular joint and cervical spine treatment

In a study done in the Netherlands, it was found that the inclusion of the TMJ in the treatment of cervical conditions and headaches is rare (von Piekartz and Lüdtke, 2011). In the past, it has also been acknowledged that the effect and role of treating the TMJ in this population is not known (von Piekartz and Lüdtke, 2011).

Techniques that are commonly used to treat TMD are soft tissue release, joint mobilisations, relaxation exercises, education on diet, stress and proper positioning of the tongue (Adelizzi, et al., 2016). In a systematic review by Adelizzi, et al. (2016), it was found in two randomised controlled trials that cervical spine manipulation led to a significant improvement in maximal pain free mouth opening. However, the statistical analysis was not reported. The manipulation was also found to significantly decrease pain according to the Visual Analogue Scale (VAS) and therefore was found to be effective in treating TMD (Adelizzi, et al., 2016). However, there is still a need for more research to investigate the effects of treating the cervical spine in people with TMD and the TMJ in those with cervical pain (Calixtre, et al., 2016).

La Touche, et al. (2009) investigated the effects of treating the cervical spine in participants with myofascial TMD. In this single cohort study, 19 participants with myofascial TMD received intervention including upper cervical flexion mobilisations, C5 central posterior-anterior mobilisations and cranio-cervical flexor stabilisation exercises. The results showed a clinically and statistically significant reduction in pain at rest and on mouth opening post intervention. There was also an improvement in participants' maximal mouth opening range of 4.5mm. This is a greater improvement compared to studies that found an increase of 2mm to 4mm on mouth opening post treatment of trigger points of the masseter muscles. Participants were also found to have an increase in pain pressure threshold of the masseter and temporalis muscles immediately and 12 weeks post cervical intervention. This suggests that treating the cervical spine has a hypoalgesic effect on the structures of the TMJ (La Touche, et al., 2009).

In a pre-test post-test study by Calixtre, et al. (2016), participants with myofascial pain received treatment including neck stretches, cervical mobilisations and deep neck flexor activation exercises. There was a statistically significant reduction in pain with some participants reaching a median of 0 on the graduate scale, the pain measuring tool used in the DC/TMD protocol. There was an improvement in participants' maximal mouth opening range by an average of 5.7mm post intervention as well as an improvement in jaw function by 7 points on the 17-point *Mandibular Functional Impairment Questionnaire* (Calixtre, et al., 2016). However, there were only 12 participants in the study thereby limiting the generalisability of the results.

A randomised controlled trial (RCT) consisting of 37 participants with mechanical neck pain had similar results where the effects of a single spinal thrust manipulation of the atlanto-occipital joint were measured compared to the control group who received manual contact placebo. Participants in the test group had a significant improvement in mouth opening ROM of 3.5mm and a moderate improvement in pain pressure threshold of the sphenoid bone (Mansilla-Ferragut, et al., 2009). This is similar to the 4mm improvement of mouth opening range after massaging the masseter muscle (Ibáñez-García, et al., 2009). Another RCT by Oliveira-Campelo, et al. (2010) explored the effects of a C1/2 spinal manipulation compared to inhibition of suboccipital muscles versus no intervention on participants with trigger points in their masseter muscle. Participants in the manipulation group had a significant improvement in mouth opening range compared to those in the soft tissue inhibition and control group who had no improvement in range (Oliviera-Campelo, et al., 2010).

Another study investigated the effects of taping the sternocleidomastoid muscle on the TMJ. This RCT included 42 participants with trigger points in their sternocleidomastoid muscles. Participants received kinesiotaping on these muscles three times and were instructed to do gentle stretches of their sternocleidomastoid muscles. The results were a significant improvement in the TMJ ROM from 39.2 mm to 41.9 mm and decrease in the myofascial pain of the TMJ from 5.10 to 1.95 on the VAS ($p < 0.05$ for both scores). The tape may have been helpful in treating trigger points in the sternocleidomastoid muscles as these trigger points can cause an imbalance of the head position and therefore imbalance of the positioning of the TMJ (Bae, 2014).

Another RCT examined the effects of cervical treatment alone versus cervical and TMJ treatment in participants who had cervicogenic headaches or symptoms of TMD (von Piekartz and Hall, 2013). The cervical treatment included cervical mobilisations, manipulations if necessary and stretches and strengthening exercises of the neck. The treatment of the TMJ was individualized to each participant and aimed to improve joint range, reduce muscle tightness and trigger points. Findings of the study were a significant reduction in pain and improvement in mobility in the TMJ group compared to the cervical group. Exact statistical analysis was not shown in the study. Participants in the TMJ group had an improvement greater than 64% after the treatment compared to 0% in the cervical group. The TMJ group also had an improvement in cervical ROM in all planes which was not present in the cervical group. Another study by von Piekartz and Lüdtke (2011) had similar findings with participants that received TMJ treatment as well as cervical treatment having a reduction in intensity of cervicogenic headaches and improvement in cervical function.

A study by Ghodrati, et al. (2019) also compared the effects of cervical treatment alone versus cervical treatment and TMJ treatment in participants with chronic neck pain. The treatment for the TMJ and cervical spine included soft tissue release, muscle energy techniques and exercises. This study found an improvement in function, pain and range of motion of the cervical spine in both groups. However, the group that received cervical and TMJ treatment had significantly greater improvements (Ghodrati, et al., 2019). The effect of treatment of the TMJ on cervical pain is further shown in a study by Walczyńska-Dragon, Baron, Nitecka-Buchta and Tkacz. (2014) where it was found that participants with neck or TMJ pain, there was a significant reduction in either pain and an improvement in cervical ROM after wearing a night occlusal splint for 3 months.

This concludes that there is sufficient evidence to show that the inclusion of the TMJ in the treatment of cervical spine conditions is effective.

2.6 Outcome measures and measuring instruments:

2.6.1 Neck Disability Index

The NDI is a patient-reported outcome measure and is commonly used to determine a patient’s perceived disability caused by their neck pain (Cleland, Childs and Whitman, 2008). The NDI is a 10-item self-administered questionnaire with each item having a score between 0 to 5 with a maximum score of 50. The higher the score, the greater the disability. The minimal detectable change of the NDI varies from 1.66 to 10.2 points and the average minimal detectable change across the studies was found to be 5/50.

In a systematic review by MacDermid, et al. (2009) the test-retest reliability of the NDI was found to be above 0.90 in most studies with a higher reliability in short term periods (0-3 days) compared to longer periods of time (MacDermid, et al., 2009). The potential reasons for the lower test-retest reliability in longer term studies is due to the fact that neck pain commonly occurs in episodes with majority of participants having quick recoveries (MacDermid, et al., 2009).

Numerous studies have found the NDI to have good construct validity with participants reporting a reduction in disability when describing themselves as improved (Cleland, Childs and Whitman, 2008). The NDI has been found to have good construct validity with The Patient Specific Functional Scale, the Neck Pain and Disability Scale and the Disability Rating Index (MacDermid, et al., 2009). A moderate but significant correlation between the Numerical Rating Scale (NRS) and NDI has been shown, indicating overall good validity of the tool (MacDermid, et al., 2009).

The NDI has also been found to have good content validity when evaluating pain and disability in participants with neck pathology (MacDermid, et al., 2009). The responsiveness of the NDI has been found to vary from 0.60 in mild cervical conditions to 0.95 in the group of participants that had improvements in their pain therefore showing that the NDI has a good ability to detect change over time. No other study has found another neck disability scale to have better responsiveness than the NDI.

The NDI has been found to be easy to read and understand and quick to administer and therefore is appropriate in a time constraint setting of the study and for participants with different literacy levels. It has also been concluded that no other tool has undergone as much validation as the NDI and therefore the NDI is the favourable tool in evaluating disability in participants with neck pain (MacDermid, et al., 2009). Therefore, clinically there is sufficient evidence to support the use of the NDI in participants with acute and chronic neck pain.

Another tool that is used to measure disability in people with neck pain is the Neck Pain and Disability Scale. The Neck Pain and Disability Scale consists of 20 questions and therefore will take longer to administer compared to the NDI. This tool explores four areas including function, emotions and activities of daily living (Chan Ci En, Clair and Edmondston, 2009). The Neck Pain and Disability Scale differs from the NDI in that it includes more specific questions that will provide more specific information on the factors causing the disability (Chan Ci En, Clair and Edmondston, 2009).

The tool has been found to have good validity of 85% if all answers are present. The tool has also been found to have high sensitivity with a minimal detectable change of three indicating it has a high ability to detect small changes (Blozik, et al., 2011). The tool has also been found to have a very good reliability with a Cronbach's alpha of 0.95 and a very good test-retest reliability of 0.97 (Bremerich, Grob, Dvorak and Mannion, 2008).

The Neck Pain and Disability Scale and the NDI have been found to have the same construct validity with both tools focussing on function as opposed to symptoms (Chan Ci En, Clair and Edmondston, 2009). Therefore, the Neck Pain and Disability Scale also has good psychometric properties but takes longer to administer than the NDI and therefore the NDI was chosen as the preferable tool.

The Copenhagen Neck Functional Disability Scale is another tool commonly used to assess neck disability and consists of 15 items and takes 10 minutes to complete. It has been found to have a good test-retest reliability with a Pearson correlation coefficient of 0.99 on the same day as retesting and 0.98 two days later (Pietrobon, et al., 2002). The construct validity had a Pearson correlation coefficient of 0.83 for pain and disability and a Spearman correlation of 0,89 when comparing participants' and doctors' assessments therefore indicating that the Copenhagen Neck Functional Disability Scale has a good construct validity (Pietrobon, et al., 2002).

The NDI was chosen as the instrument to assess disability as it was found to be the most commonly used tool in clinical research and practice with it being used in over 300 publications, translated into 22 languages and accepted by numerous committees that establish clinical guidelines (MacDermid, et al., 2009). The NDI is also commonly used in the South African setting and has been translated into Afrikaans and Zulu (Ally, 2006). The tool is also well validated and the quickest to administer which is important in this study to limit the time needed for the assessment.

2.6.2 Numerical Rating Scale

Pain is a common symptom accompanying many conditions and the assessment of pain is important in the correct diagnosis and care. Pain is subjective and therefore a reliable and valid tool is important to evaluate the progression of pain (Begum and Hossain, 2019). The VAS is a widely used tool that measures a patient's perceived level of pain. It is quick to complete, requires minimal translation, is easily understood and has good acceptability from participants. The NRS is a numeric version of the VAS and consists of a horizontal line with numbers from 0-10 ranging from no pain on the left to the worst possible pain on the right. It has been found that participants with chronic pain have a preference for the NRS over the VAS as it is easier to complete (Hawker, Mian, Kendzerska and French, 2011). The NRS is easy and quick to administer with minimal language barriers and therefore this version of the VAS was chosen to suit the population of the study which includes participants from different socio-economic backgrounds.

In a critical review, the NRS was found to have a high test-retest reliability and repeatability (Begum and Hossain, 2019). A high test-retest reliability was found in illiterate and literate participants (r=0,96 and 0,95 respectively) which is important for the participants in this study as it includes participants that are unable to read. The NRS had a higher test-retest reliability (r=0.96) compared to the VAS in illiterate participants (r=0,71) and therefore is another reason the NRS was chosen over the VAS.

The NRS has a high correlation to the VAS in participants with chronic and acute pain (Hawker, Mian, Kendzerska and French, 2011; Sirintawat, et al., 2017). The NRS was also found to have a moderate to strong correlation for pain measurement (Begum and Hossain, 2019; Hwang and Mun, 2013). The limitation of the NRS has been found to be a decreased understanding of the tool in the elderly population, which the article considers 60 years and above, due to reduced cognition (Hawker, Mian, Kendzerska and French, 2011). However, this is not a factor in this study as it only includes participants up to the age of 65 years old.

Another tool used to measure pain is The McGill Pain Questionnaire and is a more holistic approach to measuring pain. However, this was not necessary as the pain tool was chosen to measure pain and not function as the NDI was chosen for that purpose (Hawker, Mian, Kendzerska and French, 2011).

The McGill pain questionnaire consists of 78 items and takes an average of 20 minutes to complete. It has also been found that some participants find it difficult to answer the questionnaires due to the high level of language used. This was the same reason The Short-Form McGill Pain Questionnaire wasn't chosen. Even though it is a shorter version of the McGill pain questionnaire it has also been found to be difficult for participants to complete due to a lack of instructions of completion and unfamiliar words used (Hawker, Mian, Kendzerska and French, 2011). Therefore, the NRS is a quicker and more easily understood tool that measures pain.

2.6.3 Kinovea

A reduction in ROM indicates that the body part cannot move through its normal range indicating potential pathology in that joint (El-Raheem, Kamel and Ali, 2015). Kinovea is a computer programme that is used to analyse the ROM of joints. It takes images at regular intervals of a video of a person doing a particular movement.

Kinovea is a free programme and therefore is cost effective, is easy to use and provides visual feedback to the patient of their progression. Videos can be saved and accessed at a later stage and each video can be played in slow motion so that each frame can be assessed by the clinician. A line or arrow can be added to each frame so that the distance and angle required can be analysed (Elwardany, El-Sayed and Ali, 2015). No previous training is required to use Kinovea in order to obtain reliable and valid results (Puig-Diví, et al., 2019). There are free videos on YouTube explaining exactly how to use the programme.

The intra-rater reliability of Kinovea was found to be excellent with the practitioner finding very similar results when cervical extension and flexion were performed and measured with the intraclass coefficient ranging between 0.920-0.995 (Elwardany, El-Sayed and Ali., 2015). The inter-rater reliability between the three raters was also found to be excellent with great agreement between them with intraclass coefficients ranging from 0.988 to 0.997 (Elwardany, El-Sayed and Ali, 2015). A study done by El-Raheem, Kamel and Ali (2015) also found Kinovea to have good intra-rater and inter-rater reliability for measuring ROM of the wrist with intra-rater reliability ranging from 0.926 to 0.987 and inter-rater reliability ranging from 0.877 to 0.954.

In a study by Puig-Divi, et al. (2019), the validity and reliability of Kinovea from different angles and perspectives was examined. The correlation co-efficient between the three observers was found to be r=1 therefore highlighting the reliability of Kinovea. This study was also in agreement with previous studies such as the study done by Elwardany, El-Sayed and Ali, 2015 and El-Raheem, Kamel and Ali (2015) that Kinovea is a valid, reliable and accurate tool to assess data on distances and angles between co-ordinates.

The idea of using Kinovea to measure upper cervical ROM was based on a study that measured upper cervical ROM in participants with cervical pain using an electromagnetic tracker system. The system used was FASTRAK and the placement of the receiver was on the C2 spinous process (Rudolfsson, Björklund and Djupsjöbacka, 2012). Kinovea was chosen as the alternative method as FASTRAK is an American product and very expensive.

Another tool commonly used to measure cervical ROM is ‘The Cervical Range of Motion Instrument’. This is a mechanical instrument that uses inclinometers and a magnetic reference. The instrument has been found to have good validity with intraclass correlation coefficients ranging between 0.82 and 0.98 compared to an x-ray. It has also been found to have good intra-rater reliability with intraclass co-efficients ranging between 0.90 and 0.95 and inter-rater reliability with intraclass coefficients ranging from 0.58-0.99 (Elwardany, El-Sayed and Ali, 2015).

However the measurements are manually recorded in each position and therefore the patient has to maintain their head in a static position while this is being done which is often an awkward and uncomfortable position for the patient to stay in. This product is also from the United States and is expensive and therefore not chosen (Raya, et al., 2018).

The universal goniometer is a widely used tool, is cheap and easily available. However, it has been reported difficult to use as the therapist needs to stabilise the stationary arm, while moving the movable arm and record the reading. If the therapist removes the instrument to read the result, there may be movement of the instrument and therefore lowers its reliability (Elwardany, El-Sayed and Ali, 2015). The goniometer has also been found to be dependent on the examiner’s experience for accuracy and has been reported to be a tedious instrument to use with great space for error (Raya, et al., 2018).

Therefore, Kinovea was chosen as the tool to measure upper cervical ROM as it is free, easily accessible, reliable and valid.

2.6.4 Range of motion of the temporomandibular joint

The Research Diagnostic Criteria for temporomandibular disorders has been the most commonly used tool to diagnose TMD. In 2014, an updated version of the Research Diagnostic Criteria for temporomandibular disorders was created known as the DC/TMD. This was done in order to create a tool that can be used in research and in the clinical setting. The tool consists of two parts, Axis 1 and 2 which are used for screening different TMD conditions and assessing jaw function respectively (Skeie, et al., 2018).

Testing the mobility of the jaw is one of the key factors in identifying TMD and has been found to be one of the most reliable and clinically relevant tests (Schiffman, et al., 2013). Measuring the ROM of the TMJ is used as a tool to determine postoperative morbidity as well as the effectiveness of therapy (Saund, Pearson and Dietrich, 2012).

It has been found that those who underwent formal training in using the DC/TMD compared to those that did not reached similar values when using the tool (Skeie, et al., 2018). Therefore highlighting that the DC/TMD is a simple tool, easily understood and does not require prior training.

The DC/TMD gives clear instructions on how to perform the measurement:

- Cut off the end of a mm ruler so that the end of the ruler is in line with the “0” mark
- The edge of the ruler (“0”) is placed at the edge of the mandibular incisor
- The patient is in sitting with the mouth closed, lips touching and teeth not touching (Ohrbach, et al., 2013).
- The instruction given to the patient is: ‘Open your mouth as wide as you can’
- The distance between the maxillary and mandibular incisor is measured and recorded.

The normal ROM of mouth opening is 40-55mm. Trismus is defined as a reduction in mouth opening. A mild trismus is defined as a mouth opening ROM of 20-30mm, a moderate trismus as 10-20mm and severe as anything less than 10mm (Ohrbach, et al., 2013). In this study, a standard ruler was chosen to measure the ROM of the TMJ as per the guidelines of the DC/TMD.

The DC/TMD uses a ruler to measure the ROM of mouth opening. The inter-rater reliability of this measurement has been reported to be very high with examiners in a study by Skeie, et al. (2018) obtaining almost all the same values. The intraclass coefficient was also found to be above 0.75 for all mandibular movements except for lateral excursion which is a movement not assessed in this study.

It was found that participants with TMD had a reduction in ROM on mouth opening compared to those without TMD (Walker, Bohannon and Cameron, 2000). The intra-rater reliability for measuring mouth opening using a 10mm ruler was found to be acceptable with the intraclass co-efficients ranging between 0.70-0.98 and the inter-rater reliability ranging from 0.90-0.10 (Walker, Bohannon and Cameron, 2000).

The inter-examiner reliability of the DC/TMD was found to be excellent with kappa values of 0.94 for myalgia and 0.85 for myofascial pain with referral (Schiffman, et al., 2014). In a study by John and Zwijnenburg (2001), the inter-observer reliability of measuring the ROM of the TMJ mouth opening using a mm ruler was found to have an intraclass co-efficient of 0.87 and higher. Therefore, the inter-rater reliability has been found to be excellent for maximum mouth opening which is the movement measured in the study and therefore is a reliable tool to assess signs of TMD (Skeie, et al., 2018).

The DC/TMD has been found to have good criterion validity for myalgia with a sensitivity of 0.90 and specificity of 0.99. The sensitivity and specificity for myofascial pain with referral was found to be 0,86 and 0.98 respectively. A sensitivity of 0.80 and a specificity of 0.97 for intracapsular diagnoses was found. Therefore, the use of measuring TMJ ROM with a ruler is a valid and reliable tool (Schiffman, et al., 2014).

Another tool used to measure ROM of the TMJ is the Therabite range of motion scale. This tool is a cheap, cardboard scale and is specifically designed to assess trismus in participants with TMD (Saund, Pearson and Dietrich, 2012). The tool was found to have excellent validity and reliability when participants measured their own ROM of the joint (Saund, Pearson and Dietrich, 2012). However, the standardized ruler was chosen as the tool to measure ROM of the TMJ due to it being cheaper and easier to access.

2.7 Conclusion

In conclusion, there is a high prevalence of neck pain with a strong correlation between the TMJ and cervical spine in terms of anatomy, biomechanics, physiology and effectiveness of treatment. People with neck pain are more likely to have TMD and treatment of the TMJ can result in improved outcomes of the neck pain. The methods used to assess pain and the effect of pain on the patient's daily life has been discussed as well as the assessment of the TMJ and upper cervical spine. However, it is clear that there is a lack of consensus on the relationship between the ROM of the upper cervical spine flexion and extension and the TMJ.

CHAPTER 3- METHODOLOGY

3.1 Introduction

This chapter describes the methodology of the research. It includes the study design, source of participants, method of calculating the sample size, sample selection including the inclusion and exclusion criteria, explanation of the instruments and outcome measures used, the procedure, ethical considerations and data analysis.

3.2 Study design

This study was a cross-sectional observational study with a comparative cohort. The researcher investigated the ROM of the TMJ on mouth opening in participants with neck pain at the same time as evaluating upper cervical ROM, neck disability and neck pain intensity. The assessment was done when participants in the test group were experiencing neck pain and when participants in the comparative group had no pain. The Strobe guidelines for an observational cross-sectional study were used as a guideline for this study (Appendix 1).

3.3 Study setting

This study was done in Johannesburg, South Africa. The testing took place at the Physiotherapy outpatient department at a government hospital, Charolette Maxeke Johannesburg Academic Hospital (CMJAH) and a private outpatient practice, Micaela Weinberg Physiotherapy, owned by the researcher.

3.4 Participants

3.4.1 Source of participants

New patients attending Micaela Weinberg Physiotherapy outpatient physiotherapy practice in Fairmount were invited to participate in the study. The participants that were eligible to be a part of the study and gave consent for their measurements to be taken, did not pay for that session.

New patients that were referred to the outpatient physiotherapy department at CMJAH were booked for the researcher to assess. These participants were booked by the physiotherapist working in the department. It was explained to each participant that, if they agreed, the first part of their session will consist of an examination by a Masters student doing their research in participants with neck pain and they will receive treatment after the assessment. If they agreed, they were given an appointment with the researcher.

The comparative group consisted of participants with no pain and therefore not seeking physiotherapy treatment. These participants were recruited at a local store in the greater Northern suburbs and also included volunteers from the physiotherapy practice. The groups were equal in size with their genders and ages matched as best as possible given the specific inclusion criteria.

3.4.2 Sample size

Data from a previous study that used a ruler in mm to measure ROM of the TMJ on mouth opening in participants with neck pain (Mansilla-Ferragut, et al., 2009) was used as a reference to ensure an adequate sample size was obtained with sufficient statistical power. Range of motion of the TMJ was chosen to determine the sample size as this is one of the main outcome measures used in this study.

Mansilla-Ferragut, et al. (2009) found a mean difference of 3,5mm pre-manipulation and post-manipulation of the atlanto-occipital joint. The effect size found in the study was 0.5. Using a statistical calculation with a power of 95% and a level of significance of 5% an effective sample size of 45 was calculated to detect a difference between the two groups. A total of 50 participants was estimated to account for potential drop outs. This included 25 participants in the test group and 25 participants in the comparison group. Figure 3-1 illustrates the method of calculation used to determine the sample size using the G*Power software:

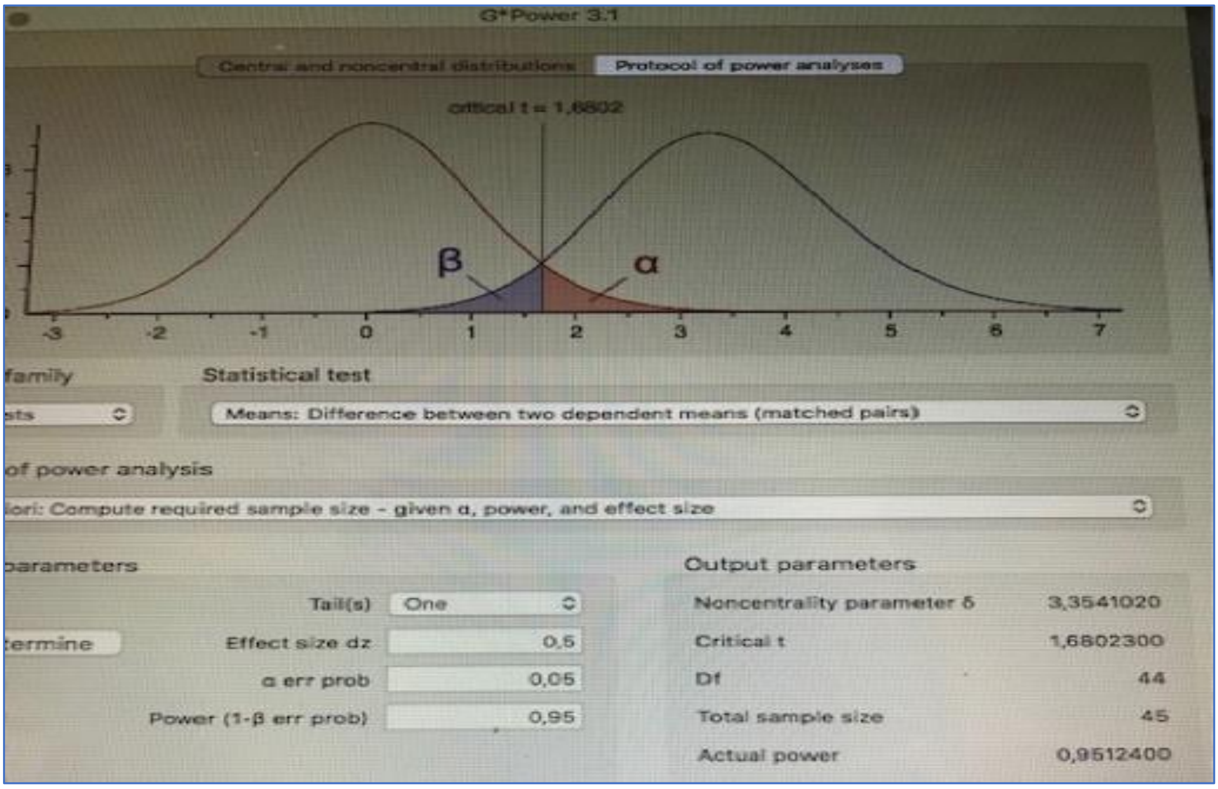

Figure 3-1: Sample size calculation

3.4.3 Sample selection

Tables 3-1 and 3-2 show the inclusion and exclusion criteria respectively. The reasons for the exclusion criteria will be outlined in the paragraphs following the tables.

Table 3-1: Inclusion criteria

Test group	**Comparative group**
• Cervical pain from the occiput to C7 with or without referral to the shoulder girdle or scapula	• No pain in any region of the body
• 18-65 years of age	

Table 3-2: Exclusion criteria

Test group	Comparative group
• TMJ clicking on mouth opening/closing • Pain in the muscles of mastication/area of the TMJ • Inflammatory arthritis • Undergoing dental/orthodontic treatment • Physiotherapy treatment on the TMJ or neck for current episode of neck pain	• Current pain in any region of the body • Neck pain in the past six months
• Previous surgery of the cervical spine or the TMJ	

The researcher excluded any participants who had previous surgery to their cervical spine or TMJ as this would cause altered biomechanics and mobility of that region and therefore influence the ROM measured. Participants were excluded if they had any signs of TMD or pain in/around the TMJ as the purpose of the study was to assess the TMJ in participants with cervical pain only. Participants with inflammatory arthritis were excluded as they are likely to present with multiple areas of pain and varying degrees of synovial joint destruction in the neck and TMJ. Participants undergoing dental/orthodontic treatment were excluded as this causes changes in the position of the TMJ and in muscle activity of the muscles of mastication, therefore predisposing them to TMJ pain or pathology (von Piekartz, et al., 2016). Participants that received treatment on their neck or jaw for this current episode of pain were excluded in order to minimize the treatment effect on the results.

Due to the body being interconnected, pain in any part of the body may cause a change in biomechanics and therefore have an influence on the TMJ (Walczyńska-Dragon, Baron, Nitecka-Buchta and Tkacz, 2014). Therefore, participants in the comparative group were required to have no pain anywhere in their body. Neck pain is a recurrent and often chronic condition and therefore participants were excluded from the comparative group if they had neck pain in the past six months (Walczyńska-Dragon, Baron, Nitecka-Buchta and Tkacz, 2014).

3.5 Instrumentation and outcome measures

Tables 3-3 and 3-4 gives an outline of the assessment tools used, outcomes measured and types of variables. The method of administering and using each tool will be discussed in section 3.5.2. The psychometric properties of each assessment tool are discussed in the literature review (Chapter 2.6). All questionnaires as well as all tests were conducted in English.

Table 3-3: Summary of questionnaires

Questionnaire	Outcomes measured	Variable	Appendix
Demographic questionnaire	• Age • Gender • Occupation • Medical conditions • Medication • Frequency and type of exercise Previous physiotherapy treatment for jaw, neck or headaches	Confounding	7
Neck Disability Index	Gives an indication of the effect of pain on the participant's activities of daily living	Neck pain and disability- independent	8
Numerical Rating Scale	Pain intensity	Neck pain- independent	9

Table 3-4 Summary of physical tests

Assessment	Outcomes measured	Variable
Standard ruler	ROM of mouth opening of the TMJ	TMJ ROM- dependent
Kinovea	ROM of upper cervical flexion and extension	Upper cervical ROM- dependent

3.5.1 Numerical Rating Scale

The NRS is an 11-point scale in which the participant rates their pain from 0-10. The NRS is commonly used to measure pain in the cervical spine. Each participant was given a line that is 10cm long and asked to rate their current pain or pain in the past 24 hours. It was explained to the patient that 0 is no pain and 10 is the worst imaginable pain. Each score was rounded up to the nearest mm. Scores between 0-5 have been found to indicate mild pain, 6-7 moderate pain and 7-10 severe pain (Hawker, Mian, Kendzerska and French, 2011).

3.5.2 Neck Disability Index

The NDI is a self-reporting questionnaire that measures the effect of neck pain on the participant's daily life. This tool is freely available and does not require specific owner permission to use. The tool is made up of 10 sections with each section consisting of different activities and possible scores between 0 and 5. The total score is out of 50, participants with a score of 0-4 are said to have no disability, 5-14 mild disability, 15-24 moderate disability, 25-34 severe disability and 35-50 complete disability (MacDermid, et al., 2009). Each participant was given the questionnaire to fill out before the objective assessment was done.

3.5.3 Demographic questionnaire

A questionnaire was designed by the researcher to determine each participant's age, gender, occupation, medical condition, medication usage as well as frequency and type of exercise. The questionnaire also included a question to determine if the participants had received any physiotherapy for their jaw, neck or headaches recently.

3.5.4 Standard ruler

A standard ruler was used to measure the TMJ ROM on mouth opening. This measurement tool is used in the DC/axis which has been found to be a valid and reliable tool in diagnosing and classifying TMJ dysfunction (Schiffman, et al., 2014). The normal ROM of the TMJ should be 40-60mm on full mouth opening and reduced ROM is considered anything below 30mm (Bae and Park, 2013; Ohrbach, et al., 2013).

To measure ROM of the TMJ, the patient was lying in supine to prevent substitution strategies, on a physiotherapy plinth with no pillow. The patient was instructed to have their lips touching, mouth closed and teeth not touching. The ruler was placed on the median clefts of the upper and lower incisal borders. The patient was instructed to open their mouth as wide as possible and the measurement was taken at the end of this range. The patient then relaxed their mouth. This measurement was taken three times and the average of all three scores was used.

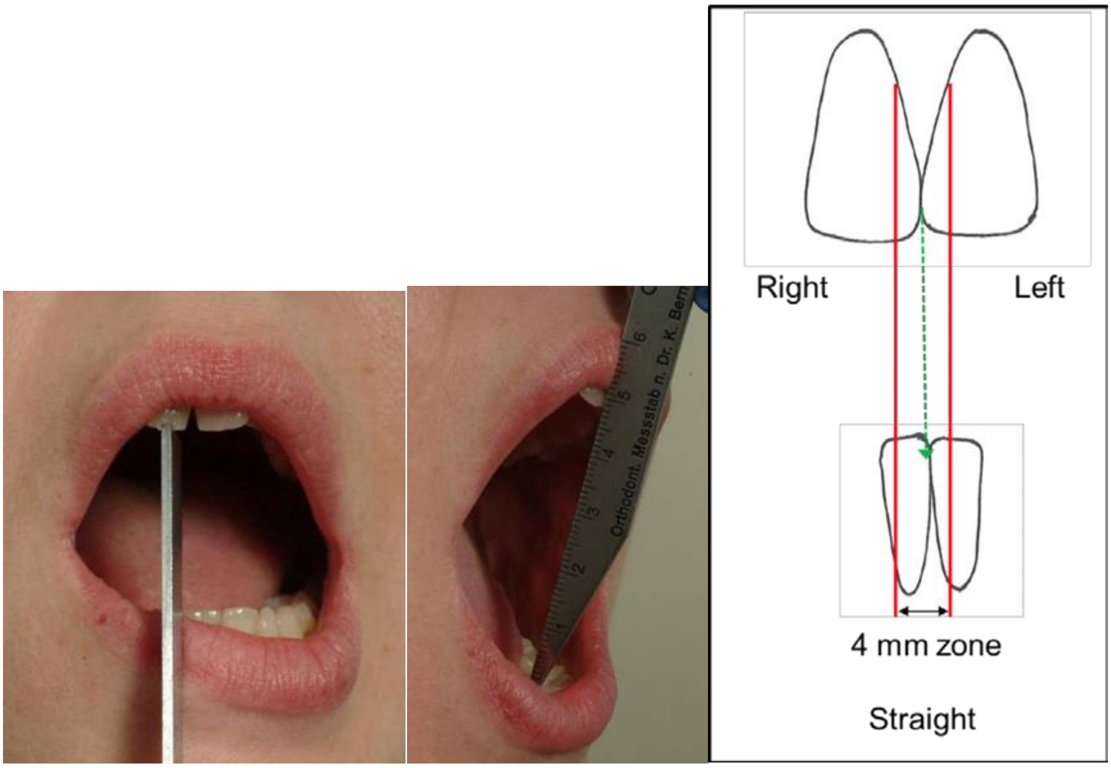

Figure 3-2: Measuring the ROM of TMJ opening (Ohrbach, et al., 2013)

3.5.5 Kinovea

Kinovea is a video player for movement analysis and was used to measure the ROM of upper cervical spine flexion and extension. Before the participant sat down, the video camera was set up on a tripod at 1.5m high and 1,5m away from the patient's feet on the recording side in the sagittal plane (Elwardany, El-Sayed and Ali, 2015). To measure ROM of the upper cervical spine, the participant sat in a chair with a backrest with their hips and back against the back of the chair and feet on the floor. A standard plastic chair with a backrest was used for both cohorts. The participant was instructed to sit upright with their head in neutral, hands on their thighs with their hips and knees flexed to 90 degrees (Elwardany, El-Sayed and Ali, 2015). The participant was asked to relax and look forward. A marker was placed on the participant's C2 spinous process.

The middle part of the lens of the camera was in line with the marker placed on the C2 spinous process. In order to ensure that the camera and spinous process were aligned, a laser was stuck on the video camera in line with the middle part of the camera's lens. The laser point at the marker placed on C2 and an inclinometer was used to ensure perfect alignment. An inclinometer was further used to ensure that the laser was directly horizontal to the middle aspect of the camera lens.

The participant was then instructed to poke their head forwards as much as possible and bring their head to neutral followed by tucking in their chin and finally bringing their head to neutral. The patient then had a 2 second rest and this movement pattern was repeated and recorded three times. The examiner sat behind the video camera while the movements were being performed. Once this was done and the participant's assessment had been completed, the examiner connected the video camera to the computer and analysed each movement on Kinovea measuring the horizontal distance of the reflective marker from neutral to upper cervical extension (head poke) and from neutral to upper cervical flexion (chin tuck). The analysis of each participant was saved on the computer in a different file and the results were recorded (Elwardany, El-Sayed and Ali, 2015).

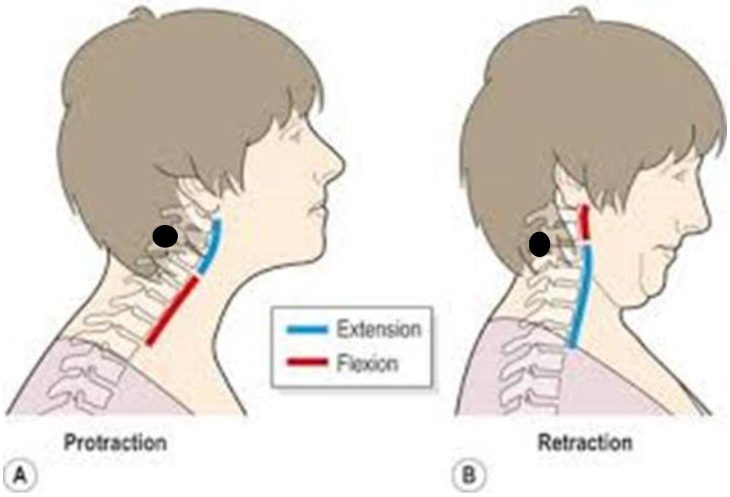

Figure 3-3: Measuring ROM of A) upper cervical extension and B) upper cervical flexion

Black dots represent the horizontal distance that will be measured during the movement

https://musculoskeletalkey.com/the-cervical-spine-4/

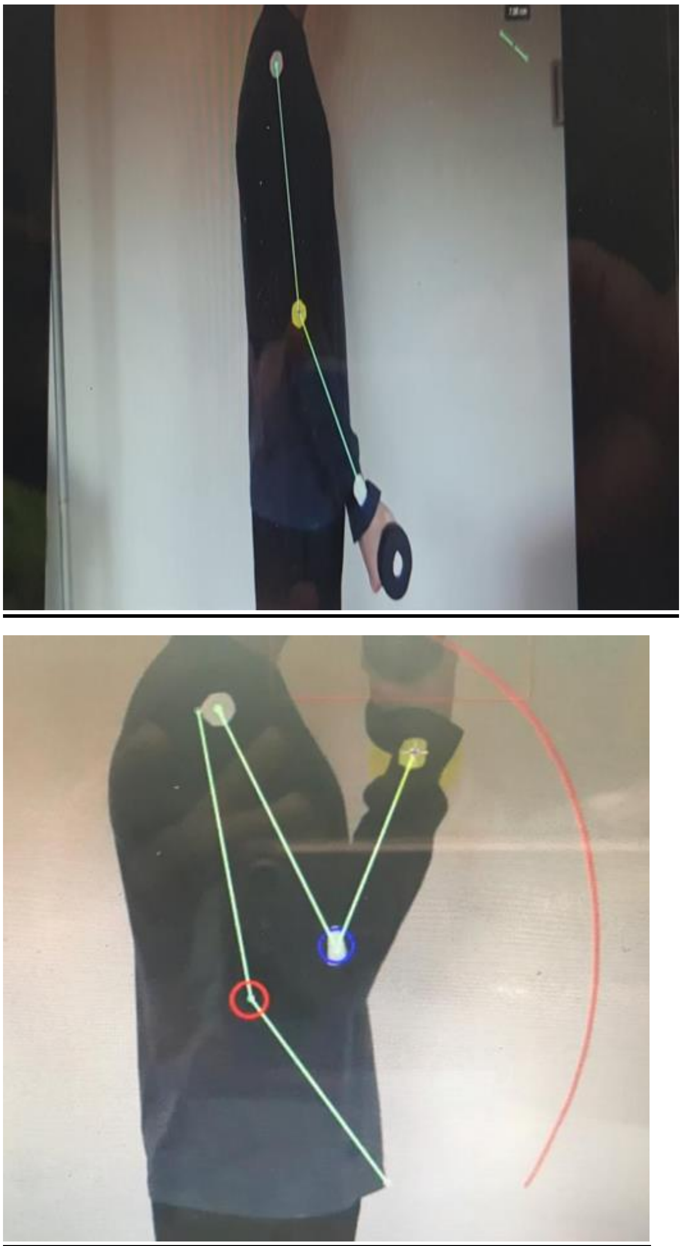

Figure 3-4: Example of Kinovea movement analysis

https://www.youtube.com/watch?v=20wOlps_Nj0

3.6 Procedure

Ethical clearance was obtained from the University of the Witwatersrand Human Resource Ethics Committee (M190473) (Appendix 2). Permission was granted by the CMJAH clinical director and the chief executive officer, where part of the study was done (Appendix 3).

3.6.1 Pilot study

A pilot study was done to determine the amount of time needed for testing, reduce risk of bias, ensure adequate understanding of the demographic questionnaire, NDI, NRS, information sheet and consent form as well as for the researcher to familiarize themselves with the study measurement tools. Data gathered from participants recruited for the pilot study were included in the main study as there were no changes to the main study. The pilot study was done with six participants which followed the procedure of the main study. This included three participants with no cervical pain and three participants with cervical pain.

3.6.2 Main study

Permission was obtained from the CMJAH physiotherapy department to collect data. New patients, matching the inclusion criteria, that were referred to the private practice (Micaela Weinberg Physiotherapy) and to the CMJAH physiotherapy department were given an information sheet (Appendix 4) and asked if they were willing to be a part of this study. Participants in the comparative group were recruited at a local store as well as volunteers of friends and family of patients attending Micaela Weinberg Physiotherapy. A local store was chosen due to restrictions of COVID and therefore a store that the researcher's family owns was chosen. Every worker was given an information sheet and was given the opportunity to choose if they want to participate. All information was provided in the information sheet that they had to read and sign before participation. Every participant that agreed was given a consent form (Appendix 5), a separate video consent form (Appendix 6) and a demographic questionnaire (Appendix 7) that they filled out in the waiting room.

The participants in the test group were also given a NDI (Appendix 8) and a NRS (Appendix 9) to fill out in the waiting area. Participants that did not understand English were told to tell the researcher and the researcher found someone in the department that could translate the information sheet, consent form and questionnaires and helped them fill out the forms. The physical assessments that were done at the CMJAH outpatient physiotherapy department were done in a curtained off section of the room. The assessments that were done at Micaela Weinberg Physiotherapy were done in the researcher's room which is a private room in the practice. All measurements and recordings were done by the primary researcher, Micaela Weinberg. The ROM of the TMJ was measured first followed by assessing the ROM of the upper cervical spine. All measurements were recorded on a measurement recording form (Appendix 10).

In order to adhere to COVID-19 regulations and ensure the safety of each participant, the therapist and participants washed their hands before and after each assessment and treatment, the therapist wore a KN95 mask and used a clean towel for each assessment. The chair and bed were sanitized between each participant and were covered with a clean towel.

3.7 Ethical considerations

No questionnaire was given or testing done before the participant gave written consent to be a part of the study as well as consent for their video to be taken. The video camera was aligned so that the recording was only done from the participant's nose to their chest, not including their eyes and therefore participants' faces were not identifiable in the videos. Participants wore face masks to further ensure deidentification and to prevent the spread of COVID-19. The videos were stored on the main researcher's (Micaela Weinberg) video camera until the data analysis was complete. All videos were then deleted from the recorder after that and stored on a password protected hard drive.

Participants did not have to endure any costs in the study. Participants attending the private practice did not have to pay for the session and participants attending CMJAH received treatment immediately after the assessment by the principal researcher.

The setting was in a private room and patients were comfortably seated during the assessment. There were no adverse effects of the measurement tools used in the study. The pilot study indicated how much time was needed for the assessment and this time was not deducted from participants usual treatment session. Participants were not penalised if they chose to drop out of the study or if they chose for their information not to be used. The participants' details were kept confidential and numbers were assigned to each participant to conceal their identity.

Participants were given feedback about their results and therefore benefited from their participation in the assessment.

3.8 Data analysis

A qualified statistician performed the statistical analysis using the IBM Statistical Package for the Social Science (SPSS) Version 26. Gender of the groups was categorical variables whereas age, VAS, NDI, ROM of the TMJ and upper cervical spine were all continuous variables and these were all tested to determine if assumptions of a normal distribution were met (Table 3-5). Categorical variables were assessed through frequencies and percentages and interval scaled variables were assessed through means and standard deviations (Table 4-3). The normality assumptions were tested by assessing the skewness and kurtosis coefficients of these variables and any variables with a value greater than 1 was regarded as being skewed (Mishra, et al., 2019).

Table 3-5: Summary of the objectives, variables and method of data analysis

Objectives: **To determine:**	Variables	Data analysis
if there is a relationship between ROM of upper cervical extension and TMJ on mouth opening	Dependent- upper cervical extension ROM, TMJ ROM on mouth opening Independent- posture, intensity of cervical pain	Pearson's correlation test
if there is a relationship between ROM of upper cervical flexion and TMJ on mouth opening	Dependent- upper cervical flexion ROM, TMJ ROM on mouth opening Independent- posture, intensity of cervical pain	Pearson's correlation test
if there is a relationship between the functional limitations of cervical pain and ROM of the TMJ on mouth opening	Dependent- functional limitations of cervical pain, TMJ ROM on mouth opening Independent- posture, intensity of cervical pain	Pearson's correlation test
if there is a relationship between the intensity of cervical pain and ROM of the TMJ on mouth opening	Dependent- intensity of cervical pain, TMJ ROM on mouth opening Independent- posture	Pearson's correlation test
If there is a difference between the group with cervical pain and without cervical pain	Dependent- intensity of cervical pain, ROM of TMJ on mouth opening, functional limitations of cervical pain, ROM of upper cervical spine Independent- age, gender	t-test

3.9 Conclusion

This cross-sectional study recruited a sample of 25 participants with neck pain and 25 participants without neck pain. The participants in the test group included patients from Micaela Weinberg Physiotherapy and CMJAH and the participants in the comparative group included volunteers from the general public. The assessment tools that were used to assess neck pain and disability included the NRS and the NDI and the assessment tools that were used to measure the ROM of the TMJ and upper cervical spine were a standard ruler and Kinovea respectively. An explanation of the procedure of data collection in the current study was given as well as the ethical considerations and statistical tests used for the data analysis.

The next chapter will discuss the results from the data analysis and will be presented to answer each objective of the study.

4. CHAPTER 4- RESULTS

4.1 Introduction

A non-experimental, observational based study was done in participants with and without neck pain in order to determine if there is a relationship between the ROM of TMJ, upper cervical spine, intensity of neck pain and disability. Assessments were done between the 29th of January 2020 - 6th of September 2020. Each assessment session was 15 minutes long and was only performed on the initial consultation.

The ROM of the TMJ was measured with a ruler when each participant's mouth was open fully. To measure the ROM of upper cervical extension and flexion each participant was asked to poke their head forwards and tuck in their chin respectively. This was recorded on a video camera and the distances between the C2 spinous process was measured using the Kinovea programme. The intensity of cervical pain was measured using the NRS where participants were asked to report their level of current pain from 0-10. Disability was determined using the NDI where participants filled in 10 questions and a score out of 50 was calculated. The scales of measures for ROM of the TMJ, upper cervical spine, pain and disability were all interval.

This chapter contains the results of the study with tables of the descriptive and demographic data as well as findings from the subjective and objective assessments. The results are discussed, interpreted and compared to other literature in chapter 5. Section 4.2 summarizes the demographics of the participants, section 4.3 presents the results of the main variables of the study, section 4.4 discusses the correlation between the variables and section 4.5 presents the results of the confounding variables.

4.2 Demographics of participants

4.2.1 Gender of participants

A total of 50 participants volunteered to participate in the study and satisfied the inclusion criteria. Of these, 25 participants made up the test group and 25 made up the comparative group. Of the total sample, 40% comprised of males and 60% of the sample comprised of females (Table 4-1).

Table 4-1: Summary of participants' gender

	Test n (%)	Comparative n (%)	Total
Males	7 (14)	13 (26)	20 (40)
Females	18 (36)	12 (24)	30 (60)

4.2.2 Age of participants

Individuals included in the sample ranged in ages from 20 to 65 with a mean age of 36.84 in both groups (Table 4-2).

Table 4-2: Summary of participants' ages

	Test (n=25)			Comparative (n=25)		
	Mean (SD)	**Range**	**Min;Max**	**Mean (SD)**	**Range**	**Min;Max**
Age (y)	36.84 (14.665)	48	21;65	36.84 (14.115)	42	20;62

y, years; SD, standard deviation

4.3 Main variables of the study

All data including the variables for pain, disability and ROM of the TMJ and upper cervical spine were tested for normality using Kolmogorov Smirnov tests and were found to satisfy the assumptions of a normal distribution. Pearson's correlations were run in order to address the research questions of the current study. Table 4-3 presents the means and standard deviation for all the variables.

4.3.1 Neck pain intensity

The test group achieved a mean of 4.76 (± 2.04) while the comparative group achieved a mean of 0(0). An independent samples t-test was run after ensuring all variables met the parametric assumptions. There were significant differences between the NRS scores between both groups, $t_{48} = 11.6$; $p < 0.000$.

4.3.2 Neck pain disability

Participants in the test group achieved a mean NDI score of 14.24 (± 7.36) compared to 0

(0) in the comparative group. The t-test revealed significant differences between the two groups, $t_{48} = 9.7$; $p < 0.000$.

4.3.3 Range of motion of the temporomandibular joint

Participants in the test group achieved a mean ROM of the TMJ of 4.24cm (± 0.68) compared to 4.14cm (± 0.58) in the comparative group. There were no statistically significant differences between the two groups ($p = 0.584$).

4.3.4 Range of motion of the upper cervical spine

There were no significant differences between the ROM of upper cervical flexion and extension between the two groups. The test group achieved a mean ROM of upper cervical flexion of 1.5952cm (0.81400) while the comparative group achieved a mean of 1.4792cm (0.509884). The test group achieved a mean ROM of upper cervical extension of 2.2732cm (0.85906) while the comparative group achieved a mean range of 2.5316cm (0.95095).

Table 4-3: Differences of the main variables between groups

	Test (n = 25)		**Comparative (n = 25)**		**Two sample t test**	***p* value**
	Mean	**SD**	**Mean**	**SD**		
NRS score	4.76	2.047	0.00	0.00		
NDI Score	14.24	7.367	0.00	0.00		
TMJ (cm)	4.2456	0.68436	4.1468	0.58021	0.551	0.584
Upper cervical flexion (cm)	1.5952	0.81400	1.4792	0.50988	0.604	0.549
Upper cervical extension (cm)	2.27	0.85906	2.53	0.95095	-1.008	0.318

NRS, Numerical Rating Scale; NDI, Neck Disability Index; TMJ, temporomandibular joint; SD, standard deviation.

4.4 Correlations of the main variables in the study

Table 4-4 summarizes the correlations of the main variables of the study and presents the results of the Pearson's correlations and significant 2-tailed test. If the *r* value was between

0-0.3 the relationship was considered weak, if the value was between 0.3-0.5, a moderate relationship correlation was assumed and a strong relationship was assumed if the *r* value was between 0.5 and 0.8 (Chan, 2003).

Table 4-4: Correlations of the main variables in the study

		NRS score	NDI score	TMJ (cm)	Upper cervical flexion	Upper cervical extension
NRS score:	**Pearson Correlation**	1	.888**	.084	.034	-.180
	Sig. (2-tailed)		.000	.563	.817	.211
NDI score:	**Pearson Correlation**		1	.064	.028	-.158
	Sig. (2-tailed)			.658	.848	.274
TMJ (cm):	**Pearson Correlation**			1	.027	-.026
	Sig. (2-tailed)				.854	.857
Upper cervical flexion (cm)	**Pearson Correlation**				1	-.092
	Sig. (2-tailed)					.527
Upper cervical extension (cm)	**Pearson Correlation**					1
	Sig. (2-tailed)					

**. Correlation is significant at the 0.05 level (2-tailed).
NRS, Numerical Rating Scale; NDI, Neck Disability Index; TMJ, temporomandibular joint.

4.4.1 Range of motion of the TMJ and upper cervical spine

A very weak, positive and non-significant relationship between ROM of the TMJ and upper cervical flexion was found, *r* = 0.27 (*p* = 0.854) (Table 4-4). A very weak, negative and non-significant association was found between ROM of the TMJ and upper cervical extension, *r* = -0.026 (*p* = -0.857) indicating that participants that had greater ROM of the TMJ had slightly less ROM of upper cervical extension. Therefore, there were no significant relationships found between the ROM of the TMJ and upper cervical spine in participants with and without neck pain.

4.4.2 Intensity of pain and range of motion of the temporomandibular joint and upper cervical spine

A weak, positive and non-significant relationship between intensity of cervical pain and the ROM of the TMJ was found with a Pearson coefficient of 0.084. A very weak, negative and non-significant association was found between intensity of pain and ROM of upper cervical extension, r (50) = -0.18. In other words, participants that had more pain had less ROM of upper cervical extension. A very weak, positive but non-significant relationship was found between intensity of pain and ROM of upper cervical flexion, r (50) = 0.34. Therefore, there was no significant relationship between intensity of cervical pain and ROM of the TMJ and upper cervical spine.

4.4.3 Neck disability and range of motion of the temporomandibular joint and upper cervical spine

A positive but very weak association was found between neck disability and ROM of the TMJ with r = 0.064 (p = 0.658). A positive but weak association was found between neck disability and ROM of the upper cervical flexion, r = 0.028 (p = 0,848). A negative and weak association was found between neck disability and ROM of upper cervical extension, r = -0.158 (p = 0.274). Therefore, no significant relationships were found between neck disability and ROM of the TMJ and upper cervical spine.

4.4.4 Neck pain intensity and disability

For the relationship between NRS scores and the NDI scores, the finding was statistically significant, r (50) = 0.88 (p < 0.000), indicating the presence of a strong positive relationship between pain and neck disability. Cohen (1988) suggests that an r value this size is reflective of a strong relationship and squaring this r value further indicates 77% of the NRS and NDI scores overlapping.

4.5 Confounding variables

4.5.1 Gender

The results are presented in Table 4.5 and show that there were no gender differences for pain, neck disability, ROM of the TMJ, upper cervical flexion and upper cervical extension. For disability, the mean for males (17.43 ±6.26) was slightly higher than for females (13 ±7.54) but none of these differences were large or significant.

Table 4-5: Results of the t test for the main variables of the study grouped into gender

	Gender	N	Mean	Std. Deviation	Std. Error Mean	t statistic	*p* value
NRS score:	**Male**	7	4.57	1.902	0.719	-2.82	0.781
	Female	18	4.83	2.149	0.506		
NDI score:	**Male**	7	17.43	6.268	2.369	1.374	0.183
	Female	18	13.00	7.546	1.779		
TMJ (cm):	**Male**	20	4.1530	0.68094	0.15226	-0.393	0.696
	Female	30	4.2250	0.60372	0.11022		
Upper cervical flexion (cm)	**Male**	20	1.5310	0.54795	0.12253	-0.053	0.958
	Female	30	1.5413	0.75667	0.13815		
Upper cervical extension (cm)	**Male**	20	2.2440	0.79631	0.17806	-1.009	0.318
	Female	30	2.5080	0.97140	0.17735		

NRS, Numerical Rating Scale; NDI, Neck Disability Index; TMJ, temporomandibular joint, N, number.

This section will present the results of the intensity of exercise done by participants as well as the differences in scores between those who did and did not exercise. The medication taken by participants will also be presented to determine if it could have an effect on the results.

4.5.2 Exercise

Participants were asked whether or not they engaged in exercise. Thirty four percent of participants in the test group exercised compared to 42% in the comparative group (Table 4.6). Of the total sample, 24% of participants did not exercise at all and 76% of participants did exercise.

Table 4-6: Summary of the number of participants who exercise

	Test n (%)	Comparative n (%)
No exercise	8 (16)	4 (8)
Exercise	17 (34)	21 (42)

Table 4-7: Comparison of frequency of exercise between the two groups

	Test n (%)	Comparative n (%)
No exercise	8 (16)	4 (8)
Exercise once per week	7 (14)	6 (12)
Exercise three to four times per week	9 (18)	11 (22)
Exercise five times per week	1 (2)	4 (8)

The frequency of exercise was higher in the comparative group compared to the test group. It was found that four participants in the test group exercise five times per week compared to only one in the test group and nine participants in the test group exercised three to four times a week compared to the comparative group (Table 4-7). The majority of participants wrote walking as the type of exercise they do but this component of the question was only answered by nine of the participants that exercised.

The main variables were also compared in participants who exercised and those who did not. The results show that participants who exercised had a lower mean score on the NRS, 4.47 (2.401) compared to 5.38 (0.744) in those who did not exercise. The mean score on the NDI was also lower in participants who exercised compared to those who did not.

Participants who exercised had greater ROM of the TMJ, upper cervical flexion and extension compared to those who did not exercise (Table 4-8).

Table 4-8: Results of the main variables of the study according to if participants exercised or not

	Exercise	N	Mean	Std. Deviation	Std. Error Mean
NRS score:	no	8	5.38	.744	.263
	yes	17	4.47	2.401	.582
NDI score:	no	8	15.00	7.270	2.570
	yes	17	13.88	7.607	1.845
TMJ (cm):	no	12	4.1000	.66899	.19312
	yes	38	4.2266	.62326	.10111
Upper cervical flexion	no	12	1.4908	1.05606	.30486
	yes	38	1.5518	.52009	.08437
Upper cervical extension	no	12	2.0508	.86481	.24965
	yes	38	2.5134	.90151	.14624

NRS, Numerical Rating Scale; NDI, Neck Disability Index; TMJ, temporomandibular joint, N, number.

4.5.3 Medication

Of the total sample, 78% of participants had no existing conditions and were not taking any medication compared to only 6% of participants from the test group taking medication such as Grandpa and Tramadol for pain and inflammation. Of the total sample, 14% of individuals had pre-existing conditions such as asthma, high blood pressure and diabetes with all of these were all under control with medication. Of those seven participants with pre-existing conditions, five were from the test group and two from the comparative group.

4.6 Conclusion

In summary, both the test and comparative groups had 25 participants with the test group having seven males and 18 females and the comparative group having 13 males and 12 females. Age was similar in both groups with a mean age of 36.84 and ranged from 20-65. The only relationship that was established was between pain and disability in the test group. There was no significant correlation between the intensity of cervical pain and ROM of the TMJ or ROM of the upper cervical spine nor between the ROM of the TMJ and upper cervical spine**.**

5. CHAPTER 5- DISCUSSION

5.1 Introduction

Previous studies have found the prevalence of neck pain over a one-year period to be 30%-50% (Hogg-Johnson, et al., 2009) with a point prevalence of 4.7% and a lifetime prevalence of 14.2% to 70% depending on the country (Hoy, et al., 2014). Majority of patients with neck pain were found to have high levels of disability and pain at a 12 month follow up with only 20% of the population with neck pain recovering well (Hush, et al., 2011). Treatment of the TMJ in patients with cervical pain has proven to improve the level of cervical pain, function and range of motion of the cervical spine (Ghodrati, et al., 2019). Therefore, owing to the high prevalence of neck pain and disability the study focused on exploring the relationship between the TMJ and upper cervical spine in order to improve the overall understanding and knowledge of the contributing factors and structures to neck pain.

This chapter will discuss the results of this study in relation to the literature and will give possible reasons for the results. Section 5.2 will discuss the demographics of the participants in both groups. Section 5.3 will discuss the main variables of the study including neck pain intensity, neck disability, ROM of the TMJ and upper cervical spine and section 5.4 will discuss the confounding variables.
In each section, differences in outcomes between the groups as well as correlations will be discussed.

5.2 Demographics

5.2.1 Age

Individuals included in the sample of the current study ranged in ages from 20 to 69 however, the average age was 36.8 years (14.2). Therefore, the younger age of the participants included could have had an impact on the results as degenerative changes of the neck are more common in adults older than 60 years with a prevalence of 80% of cervical disc degeneration in this population. A sample with an older mean age group could have had different results including higher levels of neck disability, smaller ROM of the upper cervical spine and TMJ due to degenerative changes.

In a large study, 98.1% of older participants had degeneration at, at least one vertebral level. It has also been found that cervical degenerative changes are more common in the 40-year-old age group and older which is higher than the average of participants in the current study (Wang, et al., 2019).

It has also been found that the prevalence of neck pain increases with age and is most common in women in their fifties. In a prevalence study, it was found that the average age for chronic neck pain was 48.9 years old (Blanpied, et al., 2017). The prevalence of neck pain in the 18-29-year-old age group has been found to be lower than the 60-year-old category but it is still high with a prevalence of 42-67%. The reasons for this may be due to this being a transitional period from adolescence to adulthood which may involve changes such as moving houses, changes in education and work environments as well as biological factors such as peaking of bone mass and muscle strength during this time. (Jahre, et al., 2020).

Hoy, et al. (2014) reported that the peak prevalence of neck pain is 40-45 years but the average age of participants in this study was 36.18. Reasons for the lower age may be due to sampling by convenience where participants in the comparative group were recruited from a local plumbing store and friends/family of patients attending the practice. However, in a study by (Mansilla-Ferragut, et al., 2009), the mean age of the 37 participants recruited with neck pain was 35 years which is similar to the results of this study.

5.2.2 Gender

In this study, there was a total of 18 females and seven males in the test group and 12 females and 13 males in the comparative group. The higher number of females in the test group is consistent with neck pain being more common in females with Blanpied, et al. (2017) reporting that 56% of the population studied with chronic neck pain were females. It was also found that females had a point prevalence of neck pain of 5.8% compared to only

4.0% in males (Wang, et al., 2015). The reasons for the higher prevalence in women may be due to men being less likely to report pain as well as the differences in the experience of pain relating to sex hormones (Wang, et al., 2015). Another reason for the higher number of females in the study might be that the female population in South Africa is higher than the male population, 29.7 million females compared to 28.86 males (Plecher, 2020).

This study assessed the prevalence of trismus in participants with neck pain which is one component of TMD with it being found that there is a higher prevalence of TMD in women. A study in Sweden found that TMD in women was twice as frequent compared to men with 12.7% of women compared to 6.7% of men having signs and symptoms of TMD (Bueno, et al., 2018). In a systematic review, it was found that women are twice as likely to develop TMD compared to men. The factors believed to contribute to these differences are higher work-related stress, social and cultural factors, differences in pain pressure thresholds and health seeking behaviours. However, more research is needed in these areas (Bueno, et al., 2018). Another potential reason is the higher rate of depression in women and patients with depression are more likely to develop TMD (Calixtre, et al., 2014). However, no participants in this study reported to be on anti-depressants.

5.3 Main variables of the study

5.3.1 Neck pain intensity

Pain is a subjective experience and therefore the only way to measure pain is asking the patient about their pain. The mean pain of the participants in the test group (4.76cm ± 2.047) was lower than the mean pain of participants in another study (8.0cm ±1.5) by Ghodrati, et al. (2019). One of the reasons for the higher intensity of neck pain in the study by Ghodrati, et al. (2019) may be due to their inclusion of participants with neck pain that also had signs of TMD compared to the current study where participants with signs of TMD were excluded as well as the difference in settings with the participants being recruited in Iran. However, despite those difference the mean pain of participants in the current study was similar to the mean pain (4.39cm (± 2.08)) of 482 participants with neck pain in another study (Lauche, et al., 2014).

5.3.2 Neck pain disability

The mean NDI score of participants in the test group was statistically significantly higher than participants in the comparative group. The NDI scores were found to be much higher in participants with neck pain in two other studies with a mean NDI of 33.1 (±17.2) (Chan Ci En, Clair and Edmondston, 2009) and 34.7 (± 6.4) (Ghodrati, et al., 2019) compared to the participants in the current study with a mean NDI score of 14.24 (± 7.367). This shows that impact of the participants' neck pain in the present study had a lower impact on their daily life compared to other studies. Even though the NDI scores were lower compared to other studies it has been shown that a score higher than 15 on the NDI indicates that the neck pain is impacting the person's life enough to cause a disability. Of the total participants in the test group, 40% had an NDI score greater than 15 and therefore it is evident that there is a high impact of neck pain on the participants' daily functions.

A study comparing the ROM of the TMJ and neck disability in four groups found that participants with no neck pain had a score of 2.38 (1.19) on the NDI; participants with both neck pain and TMD had a score of 9.61 (3.22); participants with neck pain only had a score of 6.53 (1.45) and participants with TMD had a score of 2.30 (1.43) (Packer, et al., 2014). The results of this study show that participants with TMD and neck pain had a higher NDI score than those with neck pain only. The score of those with neck pain only was lower than the participants in the current study (14.24 compared to 6.53). A potential reason for this is that the study only included participants aged between 18-40 which may mean that the inclusion of older age participants in the current study may be the reason that there are higher levels of disability.

The same study found no statistically significant relationship between the ROM of the TMJ on mouth opening and NDI, however all these participants had mild disability on the NDI (Packer, et al., 2014). These findings are similar to the findings of the current study that found no significant association between ROM of the TMJ and score on the NDI in participants with neck pain.

However, in a study by Figueiredo, et al. (2021), majority of the 80 participants included with mixed TMD were found to have mild neck disability scores on the NDI. Mixed TMD is TMD caused by both the joints and muscles of the TMJ. There was also a moderate correlation (0.6 - 0.8) between neck disability and the Temporomandibular Index in participants with TMD ($p < 0.05$). The Temporomandibular Index includes range of mouth opening as one of its components and therefore can be compared to the ruler used in the current study. Another finding of this study was the moderate correlation between the severity of TMD and the severity of neck disability in participants with TMD. Therefore, although the current study found no relationship between the ROM of mouth opening and neck disability in patients with neck pain, a correlation between neck disability in patients with mixed TMD has been found (Figueiredo, et al., 2021).

5.3.3 Range of motion of the temporomandibular joint

The mean ROM of the TMJ on mouth opening for both the test and comparative group in this study were within the lower limits of the normal range (4-5cm). The mean ROM for the test group was 4.2456cm (0.68436) and the comparative group was 4.1468cm (0.58021). Therefore, participants with neck pain did not have reduced ROM of the TMJ compared to those without neck pain. No relationship between the ROM of the TMJ and cervical pain intensity and disability were found.

In a previously mentioned study by Packer, et al. (2014), the ROM of the TMJ was measured in four groups, group one included participants with no cervical or TMJ pain, group two were participants with neck pain and TMD, group three had TMD and no neck pain and group four had neck pain and no TMD. The maximum mouth opening for group one was 53.15mm (5.59), for group two 52.00mm (8.98), group three 6.53mm (8.99) and group four 53.46mm (5.60). There was a statistically significant difference between groups one and three and groups three and four showing that participants with neck pain only, had a greater ROM of the TMJ on mouth opening compared to participants with TMD. This is similar to the results of the current study which found that participants with and without neck pain had similar ROM of mouth opening.

Another interesting finding was that participants with neck pain and TMD had a non-significant lower ROM of the TMJ on mouth opening compared to those without pain and those with neck pain only (Packer, et al., 2014). The findings of the current study are in agreement with the findings from the study by Packer et al. (2014) that patients with neck pain only do not have reduced ROM of the TMJ on mouth opening and therefore there is no relationship between the intensity of cervical pain and ROM of the TMJ.

The results of the ROM of the TMJ on mouth opening in participants of the study by Packer, et al. (2014) had a higher average range compared to participants in both groups of the current study. This may be due to their inclusion of only women between the ages of 18-40 compared to the current study which included males and females between the ages of 18-65.

The results of a study by La Touche, et al. (2011) showed that participants with myofascial TMD had greater ROM of the TMJ on mouth opening in the forward head poke position (43.7 mm), less range in the neutral head position (40.8 mm) and the lowest range when the head was retracted (36.8 mm).

A potential reason for the greater ROM of the TMJ in the test group of the current study is that participants with neck pain more commonly have a forward head posture and therefore, even though the measurement was done in supine, the participants in the test group may have had more upper cervical extension compared to participants in the control group (Evcik and Aksoy, 2004).

5.3.4 Range of motion of the upper cervical spine

The current study measured upper cervical extension and flexion and found no significant relationship between the ROM of the upper cervical spine and TMJ. This is similar to the results of a study by Greenbaum, Dvir, Reiter and Winocur (2017) that found no statistically significant relationship between intensity of pain, ROM of the TMJ on mouth opening and ROM of the upper cervical spine in participants with TMD.

In another study, the mobility of the upper cervical spine (C1-3) was compared in participants with and without TMD and found that participants with TMD had more hypomobility of these joints compared to the control group (De Laat, Meuleman, Stevens and Verbeke, 1998). The difference between these studies and the current study is that they included participants with TMD and not cervical pain. The profile of these patients are different compared to the current study as patients with TMD have been found to have increased psychosocial stress and therefore a reduced ROM of the upper cervical spine was found in participants with TMD but a reduced ROM of TMJ in participants with cervical spine pain was not found (Calixtre, et al., 2014).

In the current study, the participants in the test group had a greater mean ROM of upper cervical flexion compared to the comparative group while the comparative group had a greater mean ROM of upper cervical extension compared to the test group. A potential reason for this may have been that the resting position of the head in the participants of the test group was already in upper cervical extension (forward head poke). Therefore, there was a greater distance for these participants to move into upper cervical flexion and a shorter distance for them to move into upper cervical extension as that was their current resting position. It was also found in the study that participants that had higher levels of pain had less ROM of upper cervical extension.

It has been found that a forward head posture occurs due to weakness of the anterior neck muscles, tightness of the upper trapezius and sternocleidomastoid muscles and therefore patients with this posture are predisposed to neck pain (Evcik and Aksoy, 2004). Weakness of anterior neck muscles (deep neck flexors) associated with the forward head posture has been found to be higher in participants with neck pain compared to those without neck pain on the Cranio-cervical Flexion Test. Therefore, participants with neck pain included in this study are likely to have had weakness of their anterior neck muscles and therefore contributing to the forward head posture (Jull, O'Leary and Falla, 2008). This may explain why participants in the test group had a greater range of upper cervical extension compared to flexion as the upper cervical spine is in extension in a head poke position .

The prevalence of this posture in patients with neck pain has been found to be 37% with 58% being females and 42% being males. In a study of 108 healthy adults, 81.4% of the participants had a neutral head posture with 18.51% of participants having a forward head posture further emphasizing that participants with no neck pain are less likely to have a forward head posture (Talati, Varadhrajulu and Malwade, 2018). The lack of instructing a neutral positioning of the head in the current study may be one of the reasons that there was no difference between ROM of the upper cervical spine in both groups compared to other studies that found a reduction in participants.

5.4 Confounding variables

Neck pain is associated with many factors and therefore it is important that the confounding variables are analysed. The confounding variables were determined by the demographic questionnaire however more research is required to further explore their impact on neck pain.

5.4.1 Exercise

No statistically significant differences in ROM, VAS and NDI scores were found between the participants who exercised and those who did not. In this study, participants in the test group exercised less compared to participants in the comparative group. This is in line with research by Hogg-Johnson, et al. (2009) that found that people who exercised had a reduced risk and a better prognosis of neck pain. The type of exercise was not clearly documented by most participants and thus additional research could explore whether different types of exercise affects neck pain and how individuals with neck pain use exercise instead of just reporting on the frequency of exercise.

In a systematic review by de Campos, et al. (2018), five RCTs were analysed and the results showed that there is moderate evidence to support an exercise programme substantially reduces the onset of a new episode of neck pain.

5.4.2 Medication

There was a low percentage of participants (6%) that took pain medication (Tramadol, Panado, Baclofen). These three participants were in the test group. A study of people with back and neck pain in the United States showed that 73% of people had taken non-steroidal anti-inflammatory medication in the past twelve months for their pain compared to only 2% of participants in the current study; 50% took pain medication compared to 2% in the current study (Mikulic, 2018). Given that such a small percentage of participants were using pain medication, the sample is reflective of a group that only experience mild pain and therefore appropriate for the current study.

6. CHAPTER 6- CONCLUSION AND RECOMMENDATIONS FOR FUTURE RESEARCH

6.1 Conclusion

This study aimed to determine if there is a relationship between the ROM of the TMJ and upper cervical spine in patients with neck pain. Further objectives were to determine if there was a relationship between the ROM of the TMJ and intensity of cervical spine as well as the impact on functional limitations. The final objective was to compare the outcomes between the group with cervical pain and without cervical pain. The observational study was done in both a private practice and CMJAH. Participants were asked to fill in a Numerical Rating Scale and Neck Disability Index after giving consent to participate in the study. The primary researcher then assessed each participant's ROM of the TMJ with a ruler and ROM of upper cervical spine by asking each participant to poke their head forwards and tuck in the chin while recording the movement and later analysing it on Kinovea.

The results show that there is a significant relationship between the VAS and NDI in participants with neck pain. The study also shows that participants with neck pain have a larger range of upper cervical extension and smaller range of upper cervical flexion compared to participants with no neck pain. There was a larger ROM of the TMJ on mouth opening in participants with neck pain compared to those without neck pain. These findings may be due to different starting positions of the neck when measuring the range of the upper cervical spine as well as different degrees of upper cervical extension when measuring the ROM of the TMJ in supine.

6.2 Strengths of this study

The study used well validated and reliable tools to measure pain, disability, ROM of the TMJ and neck. All the tools utilised are easy to access for the results to be reproduced and to be used in clinical practice. The study included participants in the government and private sectors therefore making the results more generalisable to populations of different socio-economic statuses.

This is the first research known to assess upper cervical ROM using the Kinovea tool. The same order of measuring was done for all participants in the test and control group in order to reduce any variance caused by a change in order. The same instructions were given to participants in the test and comparative groups to minimize bias.

There was a low percentage of participants included in the study that used pain medication and anti-inflammatories and therefore is unlikely to influence the results of the study.

6.3 Limitations of this study

A limitation of the study is that matching of participants could have been more optimal; participants were matched as closely as possible for their age but gender was not taken into account. Another limitation is that the study did not explore factors regarding the effects of socio-economic circumstances on the intensity of neck pain and the effects on daily life such as general income and areas of work. The study was done in two varying socio-economic environments and had the potential to analyse if there is a difference between the two groups. There were communication barriers in the study with some participants not speaking English as their first language which could have resulted in inaccurate reporting of pain and disability as well as resulting in inaccurate measurements of ROM of the upper cervical spine as participants needed to actively extend and flex their head to the end of range. The study should have also included participants being literate, able to write and able to speak/understand English as inclusion criteria.

Another limitation is that the resting position of participant's heads was not recorded or corrected before measurements took place. There was also no standard neutral position to determine if participants with neck pain had a different starting head position to the participants without neck pain. This was only observed and estimated subjectively by the researcher. Another issue is that the DC/TMD protocol states the ROM of mouth opening must be measured with the patient in sitting but in the study, the ROM of mouth opening was measured with the participant lying supine.

Another potential issue is that the researcher was not blinded to which group participants were in and the researcher was the only person doing the measurements and therefore there is a risk of bias. The researcher was familiar with some of the participants especially the ones in the test group done at her private practice as well as with some participants in the comparative groups. This could have led to coercion bias. The participants were not blinded to which group they were in as it related to their condition which could have led to bias during the subjective assessments.

6.4 Recommendations for future research

Future studies can be done to determine if participants with neck pain have an increased upper cervical extension ROM when taking into account the resting position of the head. Further studies can also be done in other languages to ensure optimal participation. The Wong Baker Faces Pain Scale can also be used in future studies to reduce language barriers that may arise from the NRS. This can also be done in participants with TMD and participants with TMD and cervical pain. Future studies can explore if there is a connection between participants type of work and the ROM of the TMJ and upper cervical spine. Studies can also be done to determine any correlations with other areas including the shoulder girdle in participants with TMD. Further research can also take into account the limitations of this study and ensure both researcher bias and double blinded measurements are put in place in order to ensure that the research is objective and fair.

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8. CHAPTER 8- APPENDICES

8.1 Appendix 1- Strobe checklist

STROBE Statement—checklist of items that should be included in reports of observational studies

		Item No	Recommendation
Title and abstract		1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
			(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction			
Background/rationale	✓	2	Explain the scientific background and rationale for the investigation being reported
Objectives	✓	3	State specific objectives, including any prespecified hypotheses
Methods			
Study design	✓	4	Present key elements of study design early in the paper
Setting	✓	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	✓	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
			(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	✓	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	✓	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias		9	Describe any efforts to address potential sources of bias
Study size	✓	10	Explain how the study size was arrived at
Quantitative variables	✓	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	✓	12	(*a*) Describe all statistical methods, including those used to control for confounding
			(*b*) Describe any methods used to examine subgroups and interactions
			(*c*) Explain how missing data were addressed
			(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
			(*e*) Describe any sensitivity analyses

Continued on next page

Results		
Participants	13* ✓	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14* ✓	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
	✓	*Cross-sectional study*—Report numbers of outcome events or summary measures
Main results	16 ✓	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results ✓	18	Summarise key results with reference to study objectives
Limitations ✓	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation ✓	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability ✓	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

8.2 Appendix 2- Ethical clearance certificate

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

R14/49 Miss Micaela Gruzin

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M190473

NAME: (Principal Investigator)	Miss Micaela Gruzin
DEPARTMENT:	School of Therapeutic Sciences Micaela Gruzin Physiotherapy Practice - Sandton and Glenhazel Charlotte Maxeke Johannesburg Academic Hospital Physiotherapy Department
PROJECT TITLE:	The relationship between range of motion of the temporomandibular joint and upper cervical spine in patients with cervical pain
DATE CONSIDERED:	26/04/2019
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	14/10/2019

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in **April** and will therefore be due in the month of **April** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature ____________ Date ____________

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

8.3 Appendix 3- Permission to perform research at Charlotte Maxeke Johannesburg Academic Hospital

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

CHARLOTTE MAXEKE JOHANNESBURG ACADEMIC HOSPITAL

Enquiries:
Ms. N. Mzila
Office of the Clinical Director
Email: Nolwazi.Mzila@gauteng.gov.za
Tell: (011): 488-4812
30th July 2019

Dear Micaela Gruzin

STUDY TITLE: **The Relationship between Range of Motion of the Temporomandibular Joint and Upper Cervical Spine in Patients with Cervical Pain.**

Permission to review patient file for conduction of the above mentioned study is provisional approved. Your study can only commence once Ethics approval is obtained. Please forward a copy of your Ethics Clearance Certificate as soon as the study is approved by the Ethics Committee for the CEO's office to give you the final approval to conduct the study.

Supported / ~~not supported~~

Dr. M.I. Mofokeng
Clinical Director
DATE: 30/07/2019

Approved / not approved

Ms. G. Bogoshi
Chief Executive Officer
DATE: 31.07.2019

8.4 Appendix 4- Information sheet

The Study title: The relationship between range of motion of the temporomandibular joint and upper cervical spine in patients with cervical pain.

Good day,

My name is Micaela Weinberg and I am doing research to determine if there is an association between range of motion of the temporomandibular joint and the upper part of the neck in people with neck pain. This is being done as a partial requirement to complete my MSc degree in Physiotherapy at the University of the Witwatersrand.

Neck pain is a common problem and it has been found that 22-70% of the population will have a lifetime of neck pain. This study will provide more insight into the structures affected in people with neck pain and therefore improve physiotherapy treatment and outcomes.

I would like to invite you to participate in this study which will consist of the participant filling out a short questionnaire and a short pain scale. This will be followed by the participant performing three neck and jaw movements for an average of two minutes. The total amount of time it will take to fill out the questionnaires and perform the neck and jaw movements will be approximately 10 minutes. The questionnaires are related to your neck pain and how it affects your daily life. The movements you will perform will be mouth opening and closing three times, while lying down and this will be measured with a ruler. The neck movements will include performing a chin poke and tuck three times in sitting. Before this movement, light reflective markers will be placed on your neck so that it is possible to record the movement. The three neck movements will be recorded with a video camera and measured using a video analysis programme called Kinovea.

The study involves no foreseeable risks and although you will not benefit directly from participating in the study, the information collected based on your movements will improve future physiotherapy assessments and treatments of the neck and jaw.

Your participation in the study is voluntary and you are under no obligation to participate in the study. If you wish to withdraw at any time, you may do so. It will be of priority to keep your information confidential and your identity will not be disclosed in the write up of the study or in any publications of the study.

Please call me, the researcher, if you have any questions, worries or complaints on 0767882031.

If you have any concern over the way the study is being conducted please contact the Human Research Medical Ethics Committee.

Chairperson: Professor Clement Penny: 011 717 2301, . Committee secretariat: 011 717 2700/1234, and Rhulani.Mukansi@wits.ac.za.

8.5. Appendix 5- Consent form

I, ___________________________________ agree to participate in the study as described to me in the information sheet. I have read the information sheet and fully understand what the study entails. I hereby agree to complete the required questionnaires and consent to the video recording of my neck movements.

Participant: _______________________________ Date: ______________________

Researcher: ___________________________ Date: ______________________

8.6 Appendix 6- Video consent form

I, ________________________________ agree for the primary researcher, Micaela Weinberg, to record my neck movements using a video camera. I understand that the recording will be filmed from my nose to my chest and will not include any imagery of my eyes. I will wear a face mask to further ensure the de-indentification of my face. These recordings will be deleted after data analysis which will be completed, at the latest by December 2021.

Participant: ____________________________ Date: ____________________

8.7 Appendix 7- Demographic questionnaire

Please fill in the following information.

This information is confidential and your personal details will not be disclosed.

Participant number: ____________________

Age: ____________________

Gender: ____________________

Occupation: ____

Medical conditions/co-morbidities: ___________________________________

Medication (please specify if/what medication you have taken in the past 24 hours):

____

Do you exercise? If yes, please state how many times a week and what exercise you do:

____

Have you received any physiotherapy treatment for your jaw, neck or headaches? If yes, please specify and state how many sessions:

____

____

8.8 Appendix 8- Neck Disability Index

Neck Disability Index

Office Use Only

Name ______________________________

Date ______________________________

This questionnaire has been designed to give us information as to how your neck pain has affected your ability to manage in everyday life. Please answer every section and **mark in each section only the one box that applies to you**. We realise you may consider that two or more statements in any one section relate to you, but please just mark the box that most closely describes your problem.

Section 1: Pain Intensity

☐ I have no pain at the moment
☐ The pain is very mild at the moment
☐ The pain is moderate at the moment
☐ The pain is fairly severe at the moment
☐ The pain is very severe at the moment
☐ The pain is the worst imaginable at the moment

Section 2: Personal Care (Washing, Dressing, etc.)

☐ I can look after myself normally without causing extra pain
☐ I can look after myself normally but it causes extra pain
☐ It is painful to look after myself and I am slow and careful
☐ I need some help but can manage most of my personal care
☐ I need help every day in most aspects of self care
☐ I do not get dressed, I wash with difficulty and stay in bed

Section 3: Lifting

☐ I can lift heavy weights without extra pain
☐ I can lift heavy weights but it gives extra pain
☐ Pain prevents me lifting heavy weights off the floor, but I can manage if they are conveniently placed, for example on a table
☐ Pain prevents me from lifting heavy weights but I can manage light to medium weights if they are conveniently positioned
☐ I can only lift very light weights
☐ I cannot lift or carry anything

Section 4: Reading

☐ I can read as much as I want to with no pain in my neck
☐ I can read as much as I want to with slight pain in my neck
☐ I can read as much as I want with moderate pain in my neck
☐ I can't read as much as I want because of moderate pain in my neck
☐ I can hardly read at all because of severe pain in my neck
☐ I cannot read at all

Section 5: Headaches

☐ I have no headaches at all
☐ I have slight headaches, which come infrequently
☐ I have moderate headaches, which come infrequently
☐ I have moderate headaches, which come frequently
☐ I have severe headaches, which come frequently
☐ I have headaches almost all the time

Section 6: Concentration

☐ I can concentrate fully when I want to with no difficulty
☐ I can concentrate fully when I want to with slight difficulty
☐ I have a fair degree of difficulty in concentrating when I want to
☐ I have a lot of difficulty in concentrating when I want to
☐ I have a great deal of difficulty in concentrating when I want to
☐ I cannot concentrate at all

Section 7: Work

- ☐ I can do as much work as I want to
- ☐ I can only do my usual work, but no more
- ☐ I can do most of my usual work, but no more
- ☐ I cannot do my usual work
- ☐ I can hardly do any work at all
- ☐ I can't do any work at all

Section 8: Driving

- ☐ I can drive my car without any neck pain
- ☐ I can drive my car as long as I want with slight pain in my neck
- ☐ I can drive my car as long as I want with moderate pain in my neck
- ☐ I can't drive my car as long as I want because of moderate pain in my neck
- ☐ I can hardly drive at all because of severe pain in my neck
- ☐ I can't drive my car at all

Section 9: Sleeping

- ☐ I have no trouble sleeping
- ☐ My sleep is slightly disturbed (less than 1 hr sleepless)
- ☐ My sleep is mildly disturbed (1-2 hrs sleepless)
- ☐ My sleep is moderately disturbed (2-3 hrs sleepless)
- ☐ My sleep is greatly disturbed (3-5 hrs sleepless)
- ☐ My sleep is completely disturbed (5-7 hrs sleepless)

Section 10: Recreation

- ☐ I am able to engage in all my recreation activities with no neck pain at all
- ☐ I am able to engage in all my recreation activities, with some pain in my neck
- ☐ I am able to engage in most, but not all of my usual recreation activities because of pain in my neck
- ☐ I am able to engage in a few of my usual recreation activities because of pain in my neck
- ☐ I can hardly do any recreation activities because of pain in my neck
- ☐ I can't do any recreation activities at all

Score: ____/50 Transform to percentage score x 100 = %points

Scoring: For each section the total possible score is 5: if the first statement is marked the section score = 0, if the last statement is marked it = 5. If all ten sections are completed the score is calculated as follows: Example: 16 (total scored)
50 (total possible score) x 100 = 32%

If one section is missed or not applicable the score is calculated: 16 (total scored)
45 (total possible score) x 100 = 35.5%

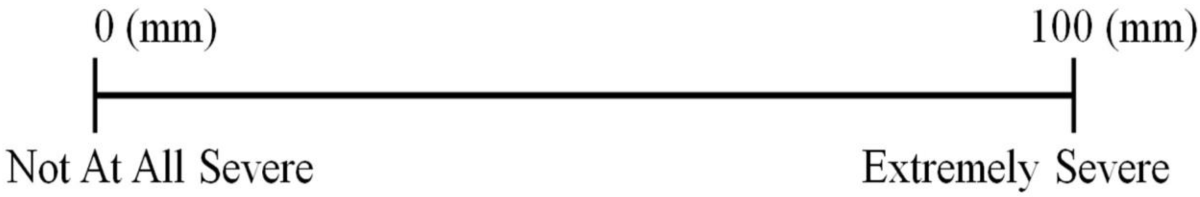
Minimum Detectable Change (90% confidence): 5 points or 10 %points

---

NDI developed by: Vernon, H. & Mior, S. (1991). The Neck Disability Index: A study of reliability and validity. Journal of Manipulative and Physiological Therapeutics. 14, 409-415

8.9 Appendix 9- Numerical Rating Scale

Note how severe you feel your disease state is with a mark (|) on the line below.



8.10 Appendix 10- Measurement recording form

Participant number: ____________________

Date: ____________________

NRS score: _______________

NDI score: _______________

TMJ mouth opening:	
Reading 1:	
Reading 2:	
Reading 3:	
Average reading:	

Cervical upper extension:	
Reading 1:	
Reading 2:	
Reading 3:	
Average reading:	

Cervical upper flexion :	
Reading 1:	
Reading 2:	
Reading 3:	
Average reading:	

8.11 Appendix 11- Turnitin report

Final Masters Research Report.

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