

# The immediate effects of dry needling levator scapulae on neck rotation range of motion

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A research thesis in partial fulfilment of the requirements for the Master of Osteopathy at  
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# Declaration

**Name of candidate:** YewJin Tan

This Thesis/Dissertation/Research Project entitled: **The immediate effects of dry needling levator scapulae on neck rotation range of motion** is submitted in partial fulfilment for the requirements for the Unitec degree of Masters of Osteopathy.

## Candidate's declaration

I confirm that:

- This Thesis/Dissertation/Research Project represents my own work;
- The contribution of supervisors and others to this work was consistent with the Unitec Regulations and Policies.
- Research for this work has been conducted in accordance with the Unitec Research Ethics
- Committee Policy and Procedures, and has fulfilled any requirements set for this project by the Unitec Research Ethics Committee.
- Research Ethics Committee Approval Number: **2011-1216**

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To everyone who has made this happen and made my Auckland ~~in~~-memorable.

# Introduction to thesis

Neck pain and dysfunction is a common complaint in the general population that is poorly understood. The anatomy of the neck has been described in standard anatomy textbooks, yet in a review of the current literature there appears to be inconsistencies regarding the involvement of specific muscles in functional neck movement (Behrsin & Maguire, 1986; Conley, Meyer, Feedback, Bloomberg, & Dudley, 1995; Mercer & Bogduk, 2000; Standring, 2008). Gross neck movements may be analysed in the cardinal movements of flexion, extension, side bending and rotation, however, the biomechanics of individual segments are complex (Mercer & Bogduk, 2000). Patient complaints are often of pain, with an associated clinical finding of movement restriction (Rosomoff, Fishbain, Goldberg, Santana, & Rosomoff, 1989) and for the investigation reported in this thesis, this movement restriction is operationally defined as a dysfunction. The relationship between neck pain and dysfunction is also poorly understood. Western medical acupuncture (WMA) has been suggested to be beneficial for neck pain and dysfunction (Guzman et al., 2009), however, the specific effects of needling have not been comprehensively researched, in particular the effect of needling on neck dysfunction. These elements of neck pain and dysfunction and the therapeutic use of needling will be investigated and a proposal will be made for further research in this field.

The neck is a complex structure consisting of bone, muscle, neurovascular and connective tissue, providing a physical conduit for transmission of air, bodily fluids and neural signalling between the head and the rest of the body. The vertebral bodies and muscular structures are the major structural components of the neck and the interplay of structure and function provide mobility while also providing protection for the sensitive neurovascular structures. With the relationship between structure and function (Moore & Dalley, 1999; Standring, 2008), a sound understanding of the anatomical structures of the neck is useful in the study of neck dysfunction.

The relationship between neck dysfunction and neck pain is not always clear (Rao, 2002). The simple contingencies for the relationship between neck pain and dysfunction are: Neck dysfunction with neck pain; neck dysfunction with no pain; pain with no dysfunction; neither pain nor dysfunction. Pain is considered to be a subjective experience that can arise in the absence of tissue damage (Merskey & Bogduk, 1994). Neck dysfunction may be present in the absence of tissue damage and may or may not be painful. While the management of neck pain has been the subject of much research, neck dysfunction has received relatively less attention (D'Sylva et al., 2010; Gross et al., 2002). Hence there is a need to investigate the management of neck dysfunction.

There is currently relatively little research on neck dysfunction, especially in the context of management with dry needling. While there is a growing body of knowledge regarding the effects of needling on functional ability (Ernst, 2006) there is relatively little research into the effects of needling specific muscles and effect on functional ability. Several muscles in the neck are involved with neck movement. Of particular interest in this study is levator scapulae due to the intimate attachments to the upper cervical spine complex that in turn contributes to approximately 30% of total neck rotation (Ferrario, Sforza, Serrao, Grassi, & Mossi, 2002). This study aims to contribute to the understanding of dry needling and its influence on functional neck movement. Hence the research question to be investigated is: What is the immediate effect of dry needling levator scapulae on neck rotation?

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# **Section 1: Literature review**

# 1 Introduction to literature review

This literature review aims to explore the use of dry needling therapy in the management of neck pain and dysfunction. To achieve this aim the prevalence of neck pain and dysfunction will first be reviewed. This will be followed by a survey of the current knowledge of the anatomy around the neck and specifically levator scapulae. The relationship between neck pain and dysfunction will be considered and a review of the management of neck pain will follow with discussion of the current conservative management approaches for neck pain and dysfunction. A brief history of needling therapeutics will be introduced and a more in depth inquiry will then center on dry needling within the current western medical context and the proposed mechanisms of action.

This review will assess published literature on the use of dry needling for neck dysfunction and relevant studies will be critically evaluated for internal and external validity. This in turn will support the research question for an investigation into the immediate effects of dry needling on neck dysfunction.

## 2 Epidemiology of neck complaints

Neck complaints are a common symptom in the population with 14.6% of people developing neck pain each year in one Canadian study (Côté, Cassidy, Carroll, & Kristman, 2004), between 11.2% and 17.8% of visits to Dutch general practices (Bot et al., 2005), and a prevalence of 14.2% to 71% in adults world wide (Fejer, Kyvik, & Hartvigsen, 2006). Across populations based in northern European countries, Canada, and the United States, the estimated incidence for visits to health centres for neck complaints were 78.5 per 1000 person year visits (Hogg-johnson et al., 2010). Of the musculoskeletal complaints lodged with primary care providers in Canada, 14% involved persistent neck pain (Crook, Rideout, & Browne, 1984).

Neck pain can have a major social and economic impact in the general population (Bassols, Bosch, Campillo, Cañellas, & Baños, 1999; Hogg-johnson et al., 2010). Examples of social impacts associated with neck pain include difficulty working, studying, performing household chores, poor emotional wellbeing and disturbed sleep patterns (Bassols et al., 1999). As an example of the economic impact of neck pain, cervical spine injuries form a significant percentage of claims lodged with the Accident Compensation Cooperation (ACC), New Zealand, accounting for 5.6% of total claims lodged and costing NZ\$164, 347, 077 in the 2011 year (Accident Compensation Corporation, 2012). Given the financial implications and its social impacts, research into neck complaints is clearly worthy of

[investigatiinvestigation.](#)

## 3 Anatomical survey of the neck

The term “neck” was deliberately chosen for use in this section to differentiate a region conventionally defined as the “neck” from the cervical spine, which is the upper 7 vertebral bones within the neck (Standring, 2008). This section will provide a brief review of the gross anatomy of the neck before more detailed consideration of levator scapulae and the structures affecting the functional anatomy influencing neck rotation.

### 3.1 Defining the boundaries of the neck

In order to study the neck the boundaries must be defined. In plain language, the neck is defined by the Oxford dictionary as “the part of a person's or animal's body connecting the head to the rest of the body” (“Definition of neck - Oxford Dictionaries (British & World English),” n.d.). This isthmus contains the skin, muscle, bone, neural and vascular structures connecting the head to the rest of the body.

#### 3.1.1 Definitions and boundaries

In anatomical terms, the neck is bordered superiorly by the superior nuchal line, laterally by the lateral margins of the neck and inferiorly by a horizontal line drawn through the first thoracic spinous process (Merskey & Bogduk, 1994). This region incorporates elements of the cranial base, the cervical vertebrae and attending ligaments, the first thoracic spine, the first rib head and the neural, vascular, muscular and connective tissue structures.

A survey of anatomy textbooks indicates descriptions of muscles influencing the neck as strictly muscles within the axial skeleton, and includes the trapezius muscle (Jenkins, 1998; Standring, 2008). No obvious rationale is given for this inclusion except trapezius is a muscle that has attachments to the neck and lies within the region conventionally defined as the neck. By this same rationale the levator scapulae muscle also lies within the defined boundaries of the neck and has attachments to the upper cervical spine. Several clinical authors (Behrsin & Maguire, 1986; Travell, Simons, & Simons, 1999; Whitfield, 2010) suggest levator

scapulae is associated with neck dysfunction and have proposed various treatment methods in order to address levator scapulae associated neck dysfunction. Hence from the anatomical location, structural attachments and potential clinical involvement in influencing neck mobility, it is suggested that levator scapulae be considered as part of the neck.

## 3.2 Anatomy

### 3.2.1 Functional anatomy of the cervical vertebrae

Bogduk and Mercer (2000) describe the functional motion of the cervical spine as derived from four significant divisions comprising the atlas, the axis, the C3-4 junction, and the remaining typical cervical vertebrae. The atlas is described as a cradle for the occiput, with strong congruence that allows only for nodding motions between the two structures. The atlanto-axial junction serves as a major weight bearing function, as well as contributing a large degree of axial rotation. The surfaces of the atlas and axis are biconvex and with rotation the atlas slides down the slope of the axis facet, nestling into the axis. The C3-4 junction has atypical cervical facet orientation, allowing the axis to sit more deeply in the body of C3. From C4 onward the segments behave as typical cervical segments with flexion and extension being the primary motion allowed by the shape of the vertebral bodies and rotation around the axis perpendicular to the surface of the facet joints.

Functionally, rotation at the atlanto-axial joint in the upper cervical spine contributes significantly towards total neck rotation (Ishii et al., 2004). Magnetic resonance imaging (MRI) investigations of the kinematics of the cervical spine in healthy individuals found (mean±SD)  $36.2\pm 4.5^\circ$  of axial rotation at the atlanto-axial joint (Ferrario et al., 2002). This axial rotation at the atlanto-axial joint represents a substantial proportion of total neck rotation when compared to the reported total range of between  $75.3\pm 8.2^\circ$  and  $81.8\pm 7.2^\circ$  in a normal population. It follows that any influences on the functional of the atlanto-axial joint have the potential to impact on the availability of overall neck rotation.

### 3.2.2 Levator scapulae

Levator scapulae is described in Grays' Anatomy as having insertions on the medial scapular border between the superior angle and the medial end of the scapular spine and to the cervical spine by tendinous slips to the transverse processes of the atlas and axis, and to the posterior tubercle of the transverse process of the third and fourth cervical vertebrae (Standring, 2008). Variants in the vertebral attachments include slips to the mastoid process, occipital bone, first or second rib, scalene, trapezius and serratus muscles (Standring, 2008). This description of levator scapulae is supported by other standard anatomy teaching texts (Jenkins, 1998; Moore & Dalley, 1999).

### 3.2.3 Involvement of levator scapulae in neck rotation

While there is reasonable consensus regarding the attachment of muscles to the cervical spine there is some inconsistency regarding the involvement of the muscles that purport to contribute to neck rotation, and this is particularly so for levator scapulae.

Grays' Anatomy suggests neck rotation is performed by sternocleidomastoid, splenius cervicis, abdominal obliques, rotatores and multifidus (Standring, 2008). A study using needle electromyography (EMG) and a subsequent analysis of force vectors suggest levator scapulae will be involved in neck rotation (Behrsin & Maguire, 1986). Another study based on MRI deduction of muscular function for cervical movement in rotation depicted splenius capitis as having the greatest contribution, with involvement of levator scapulae, longissimus capitis and cervicis; scalenus medius and anterior; and longus capitis and colli muscles (Conley et al., 1995). Despite these studies, Bogduk and Mercer (2000) recognize levator scapulae attaches onto the transverse process of the atlas but argue it does not move the atlas but rather, it serves to suspend the scapulae from its cervical spine attachments. They further suggest rotation of the atlas is brought about by activity of splenius capitis and sternocleidomastoid, with assistance from splenius cervicis. While levator scapulae is mentioned in studies

using EMG and MRI to have an involvement in neck rotation, this does not appear to be reflected in standard anatomy texts.

Interestingly, in most standard anatomy textbooks, levator scapulae is not included as a muscle of the neck despite the direct attachments to the upper cervical vertebrae (Jenkins, 1998; Moore & Dalley, 1999; Standring, 2008). No reason is given for this except for the proposed function that levator scapulae support and rotates the scapulae.

In summary, the involvement of levator scapulae on cervical rotation has not had extensive investigation. Conventional knowledge of muscular action across multiaxial joints suggest a generated movement will depend on the synergistic activity of muscles involved around the involved joints (Standring, 2008). With regards to levator scapulae and neck movement, studies utilizing EMG (Behrsin & Maguire, 1986) and MRI (Conley et al., 1995) have found levator scapulae is active during neck movement. Given the muscular attachments of levator scapulae, and the results of studies on neck functional movements, it is reasonable to suggest levator scapulae can influence neck rotation.

## 4 Neck pain and dysfunction

The anatomical sources of neck pain have been the topic of discussion and speculation within the literature (Bogduk, 2003; Rao, 2002). The relationship between neck pain and neck dysfunction is also the subject of debate. The following section will discuss neck pain, neck dysfunction and the relationship between the two.

### 4.1 Neck pain

In order to discuss neck pain, it is necessary to have a working definition of pain. An authoritative definition for pain proposed by the International Association for the Study of Pain defines pain as “an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage” (Merskey & Bogduk, 1994). Advances in the study of pain suggest an individual’s pain experiences includes combinations of biological and psychosocial aspects (Gwilym, Pollard, & Carr, 2008). Biological nociception typically involves stimulation of the neural pathway associated with detection of noxious stimuli that threaten the body. This was historically thought to be a straightforward pathway from stimulus to brain, however, more contemporary understanding of the neural pathways are complex and involve modulation at multiple levels, including the dorsal horn neurons, and supraspinal pain matrix (DeLeo, 2006). Psychosocial influences on pain have been recognized and factors such as a highly repetitive job, low social support, low job control and low job satisfaction are risk factors for neck pain (Ariëns, Van Mechelen, Bongers, Bouter, & Van der Wal, 2001). Additionally, certain psychological traits such as catastrophisation, helplessness and low self-efficacy are known to influence the perception and experience of pain (Gwilym et al., 2008). In summary, the experience of pain is the culmination of both nociception and psychosocial influences and a pain experience may not have a primary nociceptive source.

'Neck pain' is usually considered to be pain perceived as arising from the neck region and the apparent source of pain may be from a structure within or outside the defined boundaries of the neck. This is assuming there is a nociceptive source for the neck pain. Hence when clinicians are considering the possible sources of pain perceived in an area, there may or may not be a nociceptive origin within the neck, or indeed any nociceptive source at all.

#### **4.1.1 Potential sources of neck pain**

Seminal research into the nociceptive source of neck pain identified the zygapophyseal joints (Bogduk & Marsland, 1988), the cervical disc (Bogduk & Aprill, 1993), the posterior neck muscles, cervical facet joints including the atlanto-axial joints, the ligaments, dura mata of the cervical spinal cord, and prevertebral and lateral muscles of the neck as potential "pain generators" (Bogduk, 2003).

The landmark text "Myofascial Pain and Dysfunction" by Travell, Simons and Simons (1999) postulated the concept of trigger points. Travell et al (1999) propose that trigger points within a muscle may act as a source of nociception and certain muscles with trigger points may refer pain to the neck (Travell et al., 1999). Other authors have reported on myofascial trigger points as possible sources of neck pain (Fricton, Kroening, Haley, & Siegert, 1985; Miangolarra Page, Fernandez de las Penas, & Fernandez Carnero, 2005). The diagnosis of myofascial trigger points has largely been through an analysis of the presenting history and a careful physical examination with the presentation of some key findings. A summary of such key findings described in clinical texts include: The onset and description and immediate cause of pain; characteristic pain pattern distribution for trigger points; restriction of range of motion with increased sensitivity to stretch; weakened muscle with no muscular atrophy; compression reproduces the patient's symptoms, a palpable taut band corresponding with the patient's trigger point; a local twitch response with snapping palpation or rapid insertion of a needle into the trigger point site; reproduction of referred pain with mechanical stimulation to the trigger point (Lavelle, Lavelle, & Smith,

2007). There are also biochemical differences between active trigger point sites is compared to sites that contain latent or absent trigger points in muscle tissue. These differences include the presence of selected inflammatory markers, neuropeptides, cytokines, and catecholamines in active trigger point sites (Shah & Gilliams, 2008). A major criticism of the clinical utility of myofascial trigger points as a clinical entity is the lack of evidence for the reliability of diagnosing trigger points. A recent systematic review regarding the reliability of trigger point diagnosis found no studies reported adequate reliability of trigger point diagnosis (Lucas, Macaskill, Irwig, Moran, & Bogduk, 2009). However, a lack of quality in reporting of studies on reliability does not exclude myofascial trigger point as a potential source of pain, but does suggest that their clinical use may have limited utility given the poor reliability.

Regarding the source of neck pain, Bogduk (2011) somberly states in a recent anatomical and pathophysiological review that “for common, uncomplicated neck pain there [is] no data on its cause”. Hence further research into the field of neck pain and dysfunction is warranted.

## **4.2 Dysfunction**

For the purpose of clarity in this literature review, dysfunction will be defined. Dysfunction is described by the Oxford University press as “abnormality or impairment in the operation of a specified bodily organ or system” (“Dysfunction,” 2010). This impairment of a specific body system suggests the system is then unable to perform a task or function it is normally able to do. The system in this review is the neck and the function in question is the ability to rotate the head. In the context of musculoskeletal therapy assessment, dysfunction of a system is generally used to describe the reduction of available joint motion (Petty & Moore, 2001). Now this raises the questions: What is the normally available neck rotation range of motion? And when is reduced neck range of motion considered as dysfunctional? These points will be discussed in further detail in the following sections.

#### 4.2.1 Neck dysfunction

Functionally the neck must allow for a high degree of mobility to scan the environment as the special senses reside in the cranium (visual, olfactory, taste, vestibular, auditory, sensory) and the ability to scan the environment is an important evolutionary adaptation in identifying threats, locating food, and identifying potential mates. This important adaptation persists to this modern day in activities such as reversing a vehicle, avoid stepping in front of vehicles, and again in identifying potential mates. A loss of neck function, and hence an impairment in undertaking routine activities can be highly distressing and have a significant impact on activities of daily living (Croft et al., 2001). While mobility in all directions, including flexion, extension and side-bending, is important for full function, rotation is of particular interest for many activities of daily living. Hence the primary interest in this review and subsequent study is in the functional movement of rotation. For the purpose of this review, impairment in the operation of the neck or specifically a reduction of neck rotation will be considered as 'neck dysfunction'. To further investigate neck dysfunction, it is useful to establish a reference range for normal neck rotation.

#### 4.2.2 Normative values for neck rotation

Several authors have reported normative data for neck rotation by investigating cervical spine kinematics through radiographic imaging including CT scanning, MRI and goniometric measurements. Penning and Wilmink (1987) reported values of cervical rotation found in a study using computed tomography (CT) on n=26 normal subjects aged between 21 to 26 years of age. They found mean values of rotation in the cervical spine to be 1.0° (C0-C1), 40.5° (C1-2), 3.0° (C2-3), 6.5° (C3-4), 6.8° (C4-5), 6.9° (C5-6), 5.4° (C6-7), and 2.1° (C7-T1), with a total mean rotation of 72.2° and a range between 61° and 84°. Youdas et al. (1992) investigated total neck range of motion in a wide age group (ages 11 to 97 years) of healthy participants using goniometric measurements. They found mean rotation ranged from 72.3±7.0° to 44.2±14.3° and declining range with increasing age. Feipel, Rondelet, Le Pallec and Rooze (1999) investigated global cervical spine motion ranges in n=250 asymptomatic volunteers aged between

14 and 70 years of age and reported rotation in neutral of  $72\pm 11^\circ$  and cumulative rotation of  $144\pm 20^\circ$ . Ferrario Sforza, Serrao Grassi and Mossi (2002) investigated neck range of motion in  $n=60$  healthy young adults using three-dimensional digital optoelectronic instruments. Axial rotation range of motion was  $81.8\pm 7.2^\circ$  to the right and  $80.1\pm 7.7^\circ$  to the left in females, and  $79.8\pm 7.6^\circ$  to the right and  $75.3\pm 8.2^\circ$  to the left in males. Interestingly they found a significant difference in asymmetry ( $p<0.05$ ) between left and right rotation range of motion in males.

There appears to a reasonable level of agreement in the literature with regards to normative neck rotation range of motion in healthy individuals, however there is a wide range of motion that may be considered normal across a wide range of ages. Neck dysfunction has not been quantitatively defined in the wider literature and there has been little discussion regarding a specific amount of motion loss that constitutes dysfunctional neck rotation. Taking into account the definition of dysfunction, which is an impairment in the functional ability to perform a task, neck dysfunction is then taken as an inability to rotate the neck. As there is a wide range of motion and no specific quantity of motional loss to define dysfunction, neck dysfunction is then defined for the purpose of this review as a reduction of neck rotation when compared to the opposite side.

#### **4.2.3 Measurement of neck dysfunction**

Neck dysfunction may be self-reported, observed, or measured with instrumentation of varying levels of technological sophistication. Self-reporting may introduce subjective error from the participant. Observed assessment may introduce observer error. For objective measurement of neck dysfunction, goniometry equipment provides good reliability for measurement of neck rotation (Hole, Cook, & Bolton, 1995; Williams, McCarthy, Chorti, Cooke, & Gates, 2010). Measured dysfunction is dependent on the pre-defined neutral for measurement of maximal rotation to either the left or right side. Demaille-Wlodyka et al (2007) found the ability to return to self-defined neutral had a mean error of repositioning of  $4.23\pm 3.55^\circ$  for right rotation and  $4.68\pm 4.05^\circ$  for

left rotation. Hence in the measurement of neck dysfunction, this error for repositioning to a self-defined neutral position should be controlled for when assessing neck dysfunction.

### **4.3 Relationship between neck pain and neck dysfunction**

The relationship between neck pain and dysfunction is unclear (Gwilym et al., 2008; Rao, 2002). There is a wide range of neck rotation present in asymptomatic individuals whom report no pain (Feipel et al., 1999; Ferrario et al., 2002; Youdas et al., 1992). Yet there are individuals with chronic neck complaints that have no abnormal investigative findings except for a reduction in available neck movement, or in other words, have neck dysfunction (Rosomoff et al., 1989; Zwart, 1997)

Radiologic investigations may be a useful tool in chronic neck pain by evaluating the skeletal, ligamentous, or membranous structures for pathological changes and hence a potential source of pain related to pathology (Daffner, 2010). However, in the absence of pathology (eg fracture, infection, cancer) radiologic investigations are of limited diagnostic usefulness in arriving at a diagnosis or identifying and confirming anatomical source of neck pain (Bogduk & McGuirk, 2002), rather, imaging is largely useful in ruling out the presence of pathology that may result in neck dysfunction.

A study found a significant difference in neck rotation in individuals with cervicogenic headaches compared to an asymptomatic control group suggesting a relationship between neck pain and dysfunction (Zwart, 1997). However, to complicate the diagnostic process, individuals showing pathological changes with radiological examination of the neck may be asymptomatic for neck pain (Gore, Sepic, & Gardner, 1986). In a study to determine normal neck range of motion, neck dysfunction, or rotation asymmetry, was present but not associated with pain (Youdas et al., 1992). Despite progress in understanding the neurophysiology of pain and advances in diagnostic technologies, it continues to be difficult to clinically attribute uncomplicated mechanical neck pain to a

specific structure or pathological process (Bogduk, 2011). In the musculoskeletal therapy setting, pain is often associated with dysfunctional physical findings on examination, although this is often not the case and pain and dysfunction are not necessarily associated (Levangie, 1999; Severeijns, Vlaeyen, van den Hout, & Weber, 2001; Treleaven, Jull, & Atkinson, 1994). This has implications regarding the outcome measures for clinical practice and intervention. To decrease the emphasis on pain as an outcome measure of intervention, functional outcome measures such as improvements in neck mobility may be utilized in conjunction with assessment of pain (Pickering, Osmotherly, Attia, & McElduff, 2011). While it is not known if changes in functional ability will influence the experience of pain, an increase in functional ability will improve quality of life, activities of daily living and return to gainful employment (Matheson, Isernhagen, & Dennis, 2002; Moffet et al., 2004).

#### **4.4 Dysfunction and disability**

The World Health Organization defines disability as “an umbrella term, covering impairments, activity limitations and participation restrictions”. They further define an impairment as “a problem in body function or structure” (“World Health Organisation,” 2012). As such a neck dysfunction may contribute towards a disability. This is in line with a disablement model with a sequential concept of pathology, impairment, functional limitation and disability (Hermann & Reese, 2001). Hence, in order for a clinician to provide optimum care and minimize participation restrictions, it is efficient to direct therapeutic intervention towards significant dysfunctions in order to effectively address disability.

The efficacy of health interventions can be assessed with outcome measures such as pain intensity, physical function, emotional function, symptoms and adverse events, participant disposition and functional outcome measures (Dworkin et al., 2005; Pietrobon, Coeytaux, Carey, Richardson, & DeVellis, 2002; Turk, Rudy, & Sorkin, 1993). The use of functional outcome measures to evaluate disability and quality of life (Jensen, Turner, & Romano, 1991; Waehrens, Amris, & Fisher, 2010) and decreasing the emphasis on pain (McCracken & Turk, 2002)

have been associated with a favourable outcome in the treatment of chronic pain by reducing pain distress and improved daily functioning with decreased emotional responses and decreased perceptions of disability. It follows that in order to address disability, interventions should also be associated with improvements in function, such as neck rotation with less of an emphasis on pain as an outcome measure.

## 5 Management of neck dysfunction

There are diverse treatment options for the management of neck pain and dysfunction. This section will give a broad overview of options available in the non-surgical management of neck pain and dysfunction. There will be an emphasis on dry needling, expanding on the history, the current forms of dry needling and the proposed mechanisms for the effects of dry needling.

### 5.1 Management options for neck pain

The management of neck pain and dysfunction is varied and includes pharmaceutical, surgical and conservative options (Guzman et al., 2009). Surgical options are often reserved for patients disabled by pain or with a deteriorating condition (Rao, 2002). A national survey in 2007 in the United States (US) found 5.9% of US adults used complementary alternative medicines (CAM) for neck pain, back pain and other musculoskeletal conditions (Barnes, Bloom, & Nahin, 2008). A survey in Singapore over a 12-month period found 76% of respondents (n=468) used CAM, with Traditional Chinese Medicine (TCM) being the most widely used form (88%) (Lim, Sadarangani, Chan, & Heng, 2005). For neck pain with no sign of major pathology, exercise, mobilisation, acupuncture and low-level laser therapy are shown to have some short term beneficial effects (Guzman et al., 2009). CAM may be gaining popularity in the developed world as the public seeks to augment conventional care for the resolution of non-specific pain and dysfunction (Eisenberg et al., 1998). However the use of CAM treatment specifically for neck dysfunction, as opposed to CAM treatment for neck pain, is unknown.

### 5.2 Reviews for the conservative management of neck dysfunction

There is a growing body of evidence for the use of some conservative treatments for neck pain, however, there is a paucity of research regarding the conservative management of neck movement restriction or neck dysfunction as defined earlier in this literature review. This section will consider the available research

regarding the conservative treatment of neck problems, especially with regards to neck movement restriction or neck dysfunction. These reviews will be listed in chronological order.

A systematic review in 1996 found there was not enough good quality evidence to assess efficacy or effectiveness of conservative interventions for mechanical neck pain (Aker, Gross, Goldsmith, & Peloso, 1996). This review included randomized blinded clinical trials, and included studies using manual treatment, physical medicine methods, drug treatment and education. In this systematic review acupuncture and electroacupuncture ~~was-were~~ included within physical medicine modalities. This review was oriented towards neck disorders, in particular towards neck pain with no mention of dysfunction as an outcome measure.

Another systematic review into manual therapy for mechanical neck pain found no evidence from the available research in support of manipulation or mobilisation alone, and multimodal treatments involving mobilisation in combination with exercise ~~was-were~~ favoured over manipulation alone (Gross et al., 2002). This was based on studies with small sample sizes and variable methodological quality. In this review, there was little report on the changes to movement restriction or dysfunction as an outcome measure, which further highlights the lack of research in treatment modalities for neck dysfunctions..

A systematic review investigating acupuncture for neck disorders included 10 articles and found moderate evidence acupuncture relieves pain better than sham treatment at the end of the treatment (Trinh, Graham, & Gross, 2006). There was only one study in this review of acupuncture for neck disorders that used a Neck Disability Index (NDI) as an outcome measure, while the other studies primarily used a VAS to assess pain and a patient perceived effect. This study found no significant difference in NDI between groups but a criticism was this was an underpowered study. From this review of 10 studies there is evidence for acupuncture, however, within this battery of studies only one

assessed functional ability, which is suggestive of the amount of research available on acupuncture effects on dysfunction.

Hurwitz et al (2008) critically appraised 139 articles from 1980 to 2006 and found manual and supervised exercise interventions, low level laser therapy and acupuncture ~~was~~ were more effective than no treatment, sham or CAM intervention for the non-invasive treatment of neck pain. However only one study (Irnich et al., 2002) was found to investigate dysfunction with acupuncture and this study is reviewed in further detail in a subsequent section of this literature review.

Another systematic review for the management of neck pain showed support for the use of electrotherapies, laser, manual therapies involving manipulations and mobilization and exercise (D'Sylva et al., 2010). However these studies used neck pain as an outcome measure and no study included in the systematic review investigated the effects of intervention on neck dysfunction.

In summary, while the efficacy of conservative treatment for neck pain has been investigated, there appears to be an emphasis on pain as an outcome measure with relatively few investigations performing research assessing the effect of therapeutic intervention on neck dysfunction. By gauging an intervention by the therapeutic effects on neck dysfunction may have a two-fold effect of investigating effective treatment to address disability and to reduce the emphasis on therapeutic intervention as symptomatic pain management.

### **5.3 Therapeutic needling in the management of neck dysfunction**

Reviews evaluated in the previous section suggest there is growing evidence for the use of manual therapy for the treatment of neck pain (D'Sylva et al., 2010; Hurwitz et al., 2008), and there is also evidence for the use of more than one therapeutic intervention, or a multimodal approach, to address neck pain and dysfunction. There appears to be a small collection of articles for the use of needling for neck dysfunction, and this will be further investigated in this

literature review to determine the immediate effects of needling on neck dysfunction.

### 5.3.1 Introduction of acupuncture to western medical practice

The introduction of needling to western medical practice started after China demonstrated its use in the 1970s (White & Ernst, 2004). Historically acupuncture utilizes a Traditional Chinese Medicine (TCM) model that has little known congruency with the neurophysiological and anatomical models of current medical practice. Hence, the use of needling in the current neurophysiological framework is labelled as “dry needling” or western medical acupuncture (WMA) to differentiate it from “acupuncture” that utilizes a TCM model for analysis, diagnosis and treatment. Needling or dry needling differentiates itself from injection therapies that also injects a substance such as saline or local anaesthetic.

### 5.3.2 Needling in the musculoskeletal context

In the late 1980s and early 1990s needling of myofascial trigger points for musculoskeletal pain was introduced in North America and myofascial trigger points were defined as having specific characteristics of a taut band, local tenderness on palpation, and a pain referral pattern (Travell et al., 1999). A myofascial trigger point can be treated by injection of local anesthetic into focal points of tenderness in a muscle. This injection was thought to “deactivate” the trigger point and was followed up by a cold spray and stretch protocol (Lavelle et al., 2007). A key study found the effects of needling ~~was~~ were independent of the substance injected (Lewit, 1979). This suggests there was no need for injecting any substance in order to address a myofascial trigger point. Hence it raised the potential for use of acupuncture needles in order to address myofascial trigger points. Further investigations into the use of injected substances found dry needling had similar effects on myofascial trigger point pain (Cummings & White, 2001) and neck range of motion (Hong, 1994) when compared with needling with the injection of local anesthetics. The use of needling for the management of myofascial pain in musculoskeletal conditions

has been described by authors from medical, physical therapy and osteopathic backgrounds (Kalichman & Vulfsons, 2010; Moral, 2010; Rickards, 2009). These articles introduce and establish the current trends and research on needling therapeutics, and, suggest an interest in the efficacy of needling by health professions dealing with musculoskeletal complaints.

Proponents of needling in the musculoskeletal medicine context suggest different protocols in the needling management of musculoskeletal conditions (Baldry, 2002; Chan Gunn, 1996; Travell et al., 1999). While methods differ, there is a consistent theme of decreasing local muscle contraction and decreasing local palpation tenderness as well as lengthening the involved muscle.

### **5.3.3 Correlation of acupuncture points with myofascial tender points**

There has been a correlation of needling location for myofascial trigger points and TCM acupuncture points. Considerable debate exists regarding the correlation of points and there exist some polarization of opinions (Birch, 2008; Dorsher, 2008, 2009). Much of the debate comes from the use of two different models for the assessment and interpretation of patient signs and symptoms. The two models are an anatomical and physiological based model and a traditional Chinese model based on the meridian systems (Birch, 2008). One of the main arguments has been there has is no scientific evidence for a comparison between systems hence a comparison between the two models is impossible (Birch, 2008). However observation of needling location for myofascial trigger points and traditional acupuncture points recommended for musculoskeletal conditions seem to have sufficient similarities for experts in the field to continue publishing commentaries and invite discussion and further research on this topic over nearly a decade (Dorsher, 2008; Hong, 2000a).

### **5.3.4 Efficacy of TCM acupuncture for neck pain and dysfunction**

There is a growing body of evidence for the efficacy of acupuncture in the treatment of neck pain and dysfunction (Dorsher, 2011; Witt et al., 2006). However many studies utilize acupuncture in the TCM context and these studies

allow the clinician to customise the prescription of points to each individual's condition. This 'customisation' is highly dependent on practitioner training and experience and introduces a high degree of variability once taken out of context of the research conditions. The variability of points used for a given condition make for a difficult analysis regarding the specific utility of individual TCM acupuncture points except under a broad umbrella of acupuncture treatment and hence [limit](#) the predictability of results for utilizing a chosen location for needling.

#### **5.4 Current theories on the neurophysiological effects of dry needling**

The physiological mechanisms underpinning the efficacy of acupuncture are still under investigation and include the effects on local muscle contraction and the analgesic properties of needling (Yang, Li, Nilius, & Li, 2011). While there are other known effects from acupuncture, including endocrine effects (Huang, Kutner, & Bliwise, 2011), the following section of the review will focus on the musculoskeletal effects of dry needling.

##### **5.4.1 Decrease local muscle contraction**

Dry needling was thought to decrease local muscle contraction by depolarization of the involved muscle fibers hence eliciting a local twitch response (Chen et al., 2001). It has been observed that after eliciting a muscle twitch response during needling, there is an associated increase in range of motion in the involved region (Hong, 1994; Irnich et al., 2002; Lee, Chen, Lee, Lin, & Chan, 2008). This observation appears consistent with the theory of dry needling trigger points to reduce a local muscle contraction with resultant increase in range of motion (Simons, 2002).

##### **5.4.2 Dry needling motor points and correlation with acupuncture points**

There has been debate regarding the correlation between trigger points and acupuncture points. There appears to be an observational correlation between trigger points and acupuncture points (Melzack, Stillwell, & Fox, 1977). However

some authors disagree with the basis for this correlation as the two frameworks come from different conceptual (TCM and neurophysiological) backgrounds (Birch, 2008; Dorsher, 2008). There appears to be some similarities between the two systems for needling locations and this similarity is noticeable in the location described for dry needling levator scapulae with the location of acupuncture point SI14 (Whitfield, 2010). Classical TCM texts suggest SI14 can be used for “neck rigidity and inability to turn the head, generalised painful obstruction” (Deadman, Al-Khafaji, & Baker, 2007). Furthermore there are similarities between trigger point dry needling to the techniques developed by the 7<sup>th</sup> century Chinese physician Sun Ssu-Mo who described needling tender “Ah-Shi” points for restrictive and painful conditions (Hong, 2000b). Whether or not trigger points and “Ah-Shi” points are a similar [condition-finding](#) defined by different health models remains a topic of discussion, there appears to be similarities in indications, technique and outcomes.

#### **5.4.3 Analgesic effects of dry needling**

Needling is thought to have analgesic effects and has been studied intensively after its introduction to the west. A current theory for the analgesic effects of needling propose there is mechanical transduction through connective tissue, when needling that produces the “deqi” sensation, the unique sensation associated with the correct location and needling of an acupuncture point (Langevin, Churchill, & Cipolla, 2001). This results in a calcium ion waveform propagating from the point of needling (Li et al., 2011) and stimulates the release of endogenous opioids and adenosine producing an analgesic effect (Yang et al., 2011). An analgesic effect can assist with functional outcome with respect to improving joint range of motion (Atchabahian, Schwartz, Hall, Lajam, & Andreae, 2012). Hence any improvement in range of motion may be due to the analgesic effect, or due to the decrease in local muscle contraction, or a combination of the two known effects.

## 5.5 Effect of dry needling on range of motion

Myofascial trigger points are thought to reduce the length of muscles due to shortening of the sarcomeres resulting in a contractile 'knot' at the motor end plate (Simons, 2002). Needling of this contractile knot is thought to improve range of motion of its associated joint (Hong, 1994). A review of studies investigating dry needling on neck range of motion (Ga, Choi, Park, & Yoon, 2007; Hong, 1994; Irnich et al., 2002; Lee et al., 2008) will follow in the next section. Another study investigating the effects of dry needling on joint range of motion at the hip found needling gluteus maximus muscle did not result in any change in straight leg raise or hip internal rotation ROM (Huguenin et al., 2005). However this study did not report on the effects of needling gluteus maximus on other hip range of motion (other than straight leg raise or hip internal rotation). Systematic reviews investigating the effect of needling on neck ROM conclude that further high quality research is necessary before recommendations can be made regarding the efficacy of dry needling to improve neck ROM (Cummings & White, 2001; Tough, White, Cummings, Richards, & Campbell, 2009).

## 6 Review of studies on dry needling and neck rotation

In light of the use of WMA and the widespread prevalence of neck dysfunction (Bot et al., 2005; Côté et al., 2008; Fejer et al., 2006), an investigation into the current research available on the use of dry needling levator scapulae in the management of neck dysfunctions was warranted. A database search was performed to identify articles related to WMA dry needling and neck dysfunction. Relevant articles were then critically reviewed to determine the extent research has investigated the effect of dry needling on neck dysfunction, in particular neck rotation.

### 6.1 Literature search

To identify potential articles for review, a search for “dry needling” and “neck” and related keywords and phrases was undertaken using Medline (PubMed), Proquest, ScienceDirect, OVID and Google Scholar and the resulting articles were further screened to determine the relevance to the use of dry needling and its effect on neck rotation range of motion. Articles included in the reference lists of systematic reviews previously mentioned were also included for further investigation. For further evaluation, articles were required to be in English, utilize dry needling as an intervention, investigated neck ROM preferably rotation ROM and report on ROM changes post needling. Articles assessing pain were scrutinised to determine if the above criteria were met and included as appropriate. Four articles from 1994 to 2008 met the criteria for further review (see Table 1).

Table 1. Summary of studies found regarding dry needling

Author	Study design	n	Intervention	Location needed	Outcome measures	Time frame	ROM Results	Notes
Hong (1994)	Double blind and cohort study	58	-Lidocaine vs dry needling of trapezius muscle -Needling until no local twitch response able to be elicited -Lengthening using spray and stretch used for all participants post intervention	One trigger point found in the trapezius muscle	- Subjective pain intensity using VAS - Pain threshold - Cervical ROM: lateral bending to same side	Immediately and 2 weeks	Lidocaine equal to dry needling immediately after  2 week: lidocaine still showed significant effect but not dry needling  Immediate ROM changes to dry needling of $2.01^{\circ} \pm 0.89^{\circ}$ ( $p < 0.05$ )	- ROM Lateral bending - Trapezius muscle needed
Irnich et al (2002)	Prospective randomized double blind sham-controlled crossover trial	36	Distal acupuncture; dry needling MTrp with at least one local twitch response; sham deactivated laser acupuncture	Muscles of neck examined and needled if found to have trigger points. Muscles needled include trapezius, splenius cap, SCM, lev scap, paravert muscle, scalene post, scalene med, semispin cap, scalene ant	- Cervical ROM in rotation, flexion, extension and lateral flexion - Mean of all ROM reported - Motion related pain - Subjective assessment of change	Immediately before and 15 – 30 minutes after intervention	Significant difference in ROM in both dry needling ( $1.7^{\circ}$ ; 95% CI 0.2, 3.2; $p=0.028$ ) and non-local point needling ( $3.6^{\circ}$ ; 95% CI 0.3, 3.4; $p=0.014$ ).	- Multiple points needed for both dry needling (average 7.4) and non-local acupuncture (average 7.1) - Chronic neck pain and decreased mobility

Ga, Choi, Park and Yoon (2007)	Single-blinded, randomized control trial	40	Dry needling until no local twitch response elicited vs  Dry needling with addition of needling multifidus at C3-5	Upper trapezius	- Passive cervical ROM into extension, flexion side flexion and rotation using goniometer -Rotn ROM to left and right added - VAS - Wong Baker FACES pain scale - TrP pain pressure threshold	Week 0, 7, 14, 28  Measurements taken before intervention	Cervical rotation serial changes from day 0, 7, 14, 28 of 136.11°±17.70°, 132.78°±23.15°, 146.11°±17.37°, 148.06°±18.08° respectively (p=0.012)	- Upper trapezius muscle needled - Needling until no further twitch response available - Measurements taken before intervention
Lee, Chen, Lee, Lin and Chan (2008)	Open label before-after treatment	40	Needle electrical intramuscular stimulation of upper trapezius muscle and/or levator scapulae muscle	Upper trapezius and levator scapulae	- Shoulder and cervical range of motion motion -Specific ROM for each movement reported -VAS -Pressure pain threshold -Regional bloodflow. Laser Doppler flowmetry	Pre and post intervention measurements for 4 weeks at once weekly intervention	Cervical rotation left changed from 64.60° ±11.12° to 68.33°±13.84° (p=0.039) and right rotation from 63.22°±11.74° to 68.37°±11.74° (p=0.017)	- Use of electrical stimulation - No immediate response data available

### 6.1.1 The importance of the muscle twitch response to dry needling

When a needle is placed into the tender point of a taut band it may elicit a quick contraction of the taut band, or a local twitch response (Lavelle et al., 2007). Research by Hong (1994) suggests a local twitch response is necessary for an immediate positive response of increased range of motion (ROM) and change in pain intensity in patients with myofascial trigger points. This double blind controlled study was conducted to investigate the effects of dry needling and the effects of the injection of local anaesthetic into a myofascial tender point in the upper trapezius muscle. Method and design of this study appear well constructed. This study reported the upper trapezius muscle on one side was needled but did not state specifically the location of needling. Range of motion post needling was reported only to one side, in the lateral bending movement and it is uncertain which direction of lateral bending was measured. In addition, range of motion measurements were reportedly taken immediately after needling intervention. There were two significant findings from this study: 1) twitch response was necessary for there to be an increase in neck range of motion regardless of whether there was injected substance; and 2) the introduction of local anaesthetics mainly helped to reduce post-needling soreness. When no twitch response was elicited this study found little therapeutic effect with regards to range of motion or pain. Therefore the twitch response appears to be important for therapeutic effect and the local anaesthetic primarily helped to reduce post treatment soreness. The stimulation of a local muscle twitch response as an indicator of therapeutic input appears to be adopted by other studies investigating the effects of dry needling on ROM (Ga et al., 2007; Irnich et al., 2002). There appears to be reasonable evidence that eliciting a muscle twitch response during needling is necessary for therapeutic effect and should be part of research investigations.

### 6.1.2 Immediate effects of dry needling muscles in the neck

Another study investigating the use of myofascial trigger point needling also found immediate improvement of cervical ROM (Irnich et al., 2002). This study reports to have elicited at least one muscle twitch response in any muscle

around the neck area found to have tender points, an average of 7.4 muscles were needled per patient. No specific location was reported for each muscle needled. With this approach it is difficult to attribute the effect of dry needling any one particular muscle on neck range of motion, and this study would suggest dry needling all the muscles in the neck found to have trigger points would improve neck range of motion. The authors acknowledge the possibility that post treatment tenderness may have decreased measurements of neck range of motion immediately after needling. This study reported a total mean ROM instead of reporting each side (eg total rotation, rather than rotation left and rotation right) . While this suggests a generalized improvement in neck ROM, there is no reported detail with regards to which ROM direction improved and to what extent. As such it is not possible to infer which direction of range of motion was influenced by needling a specific muscle in the neck.

Although Irnich et al., (2002) reported an improvement in neck range of motion of  $1.7 \pm 1.5^\circ$  it is not clear if this improvement is clinically important as there appears to be no studies that investigate the changes of range of motion necessary for functional improvement, for the person being needled to detect the change of range of motion, or the range of motion changes a clinician can reliably detect.

### **6.1.3 Further research into dry needling upper trapezius on neck range of motion**

A single-blinded, randomized controlled trial reported by Ga et al (2007) found needling of upper trapezius improved neck flexion, rotation, side-bending range of motion but not extension. The specific location for needling of upper trapezius was not reported. While this study had a reasonable sample size ( $n=40$ ), the age of the participants (dry needling group:  $79.22 \pm 6.80$  yrs; intramuscular stimulation group:  $76.27 \pm 8.63$  yrs) was representative of an older population and not of a general population. In this study, only the upper trapezius was needled, an approach similar to the methods of an earlier study which described a similar dry needling protocol by which needling was performed until there were no further local twitch response (Hong, 1994). Reported results for ROM in

three [axisaxes](#), including rotation, and provide useful data on the impact of needling on each axis of movement. However rotation was reported as the total of left and right rotation, with no report of changes to a specific side. Furthermore it is not known if trapezius was needled unilaterally or bilateral. Thus it is not known if needling levator scapulae only on one side will have an effect on rotation, and if so to which side. This information was unable to be discerned from the published results. Data on neck range of motion after intervention was collected only on day 7 and 14 and hence does not provide data regarding the effect on range of motion immediately after dry needling.

#### 6.1.4 Investigations into needling of levator scapulae

Thus far no study has investigated the effects of dry needling levator scapulae on neck range of motion. An unblinded (both researcher and participants know which intervention is being administered), before-and-after treatment study included both levator scapulae and the trapezius muscle when investigating the effects of needle electrical intramuscular stimulation and found support for needling to improve neck range of motion (Lee et al., 2008). In this study [they the authors](#) reported either the trapezius or the levator scapulae muscle was treated with significant improvements from the first visit to re-evaluation at the 4<sup>th</sup> visit with one week between treatment sessions (right rotation from  $63.22^{\circ} \pm 11.74^{\circ}$  to  $68.37^{\circ} \pm 11.74^{\circ}$ ,  $p=0.017$ ; left rotation from  $64.60^{\circ} \pm 11.12^{\circ}$  to  $68.33^{\circ} \pm 13.84^{\circ}$ ,  $p=0.039$ ). However they do not specify which muscle was needled for the reported response, nor did they specify the location for placement of the needles. Electrical intramuscular stimulation was used for all intervention and there was no report of whether or not a local muscle twitch response was elicited during the needling. No comparison was made between needle electrical intramuscular stimulation of dry needling and dry needling only. This study reported all data was recorded for neck range of motion before and after each session with immediate responses to range of motion after intervention. However, no immediate response data was reported and only pre-intervention and post 4 week intervention data was given, hence no correlation

between side of needling and intervention change immediately after dry needling was possible.

## 6.2 Summary

There are few studies investigating the effects of dry needling on neck dysfunction. Even within these studies the differences in method and reporting make it difficult to compare results regarding the efficacy of dry needling, and even harder when specifically considering the effects on neck rotation. Each study adds to the overall picture but there is no study specifically investigating the effects of dry needling levator scapulae on neck rotation. Hong (1994) found dry needling can increase neck ROM and also determined the muscle twitch response to dry needling was important for ROM change. However he reported neck side bending angles with no mention of rotation. Irnich et al (2002) found that needling multiple muscles, including levator scapulae, in the cervical region improved ROM with but lacked sufficient detail when reporting the effects of needling on individual muscles. Ga et al (2007) found needling the upper trapezius muscle improved cervical ROM, especially if combined with segmental needling. However he reported the total range of motion with no mention of side of needling or the side of response. A study by Lee et al (2008) reported that functional improvements occurred when electrical intramuscular needling was performed to the upper trapezius muscle and levator scapulae muscle. However the combination of needling with the introduction of electrical intramuscular stimulation adds a confounder of whether the increases in ROM is due to the needling or the electrical stimulation. Thus far the results of relevant studies suggest dry needling can improve neck ROM, potentially improving rotation. What is unclear from the literature to date, is the specific needling location to achieve changes in neck rotation, and if needling levator scapulae only can improve neck rotation. Levator scapulae was only used in one study [in which](#) ~~and~~ [the](#) intervention was different (including electrical intramuscular stimulation instead of needling for muscle twitch) from previous studies. After assimilating the available literature on dry needling effects on neck rotation, and an interest

in the involvement of levator scapulae, there appears to be a rationale for further investigation.

## **7 Rationale for investigation**

Dry needling may be an effective intervention for improving neck ROM. However the parameters (target muscles, needle locations) when this will be effective is still under investigation. Also the reporting of the specific location for needling is generally not adequate in most reports. Reporting of needle locations in methods is important as this allows for study replication by other investigators, and application of the study findings within the clinical environment. Needling to upper trapezius has been previously investigated and found to improve neck ROM but not specifically rotation. Neck rotation is thought to be a functionally important movement and yet this is reported in detail in only one study (Lee et al., 2008). Unfortunately this study did not use dry needling, instead investigated the use of needle electrical intramuscular stimulation. Levator scapulae is also mentioned in previous studies but has not been investigated in detail, hence it is the focus for the experimental study reported in Section 2 of this thesis. There appears to be no study that has specifically investigated the effects of needling levator scapulae on neck rotation. Therefore the research question to be addressed in the experiment is: What is the immediate effect of dry needling levator scapulae on neck rotation?

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## Section 2. Manuscript

Note: The following manuscript was prepared in accordance with the Instructions for Authors of *Acupuncture in Medicine* [see Appendix D]. The required word limit and number of references have been exceeded in this version of the manuscript in order for a full evaluation and discussion of the results as part of the thesis.

# **The immediate effects of dry needling levator scapulae on neck rotation range of motion**

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## Abstract

*Objective:* To determine the immediate effect of dry needling levator scapulae on neck rotation.

*Design:* Within subject pre-post intervention design.

*Participants:* 31 participants (n=19 males; n=12 females; mean age  $31.7 \pm 9.96$  y) recruited from a general population completed the study.

*Methods:* Participants received a single session of dry needling to levator scapulae on one side only. Prior to needling, each participant reported current pain intensity on a visual analogue scale. Pre-test and post-test measurements of neck range of motion in rotation were taken using an electrogoniometer to both left and right sides independently. A laser pointer was used to relocate neck rotation back to a participant defined neutral. Dry needling involved insertion of a single acupuncture needle into a taut band in levator scapulae and manipulated until no muscle twitch response was able to be further elicited and there was a palpable difference in levator scapulae with respect to the taut band.

*Results:* Neck rotation relative to the side needled revealed a mean difference on the ipsilateral side of  $2.71^\circ$  (95% CI =  $1.12^\circ$  to  $4.29^\circ$ ;  $t = -3.49$ ;  $df = 30$ ;  $p = 0.002$ ) and no significant change in mean difference to the contralateral side of  $0.99^\circ$  (95% CI =  $0.29$  to  $2.27^\circ$ ;  $t = -1.58$ ;  $df = 30$ ;  $p = 0.13$ ). No significant difference was found after subcategorising by pain or dysfunction.

*Conclusion:* Dry needling of levator scapulae improves neck rotation to the same side as needling, however the clinical relevance of this increase is unclear. An approach to analysis that involves categorisation of participants by dysfunction and pain status may be useful in determining responsiveness to dry needling for functional changes, however, this requires further investigation.

Keywords (MeSH):

Neck pain; Human; Acupuncture; Treatment outcome; Range of motion; Neck pain: therapy

## Introduction

Neck pain is a common musculoskeletal problem within the general population and there many social and economic implications associated with this condition .(1) While neck pain is common, the causes of neck pain and associated loss of mobility are largely unknown.(2) A wide range of treatment options are available including pharmaceuticals,(3) pulsed electromagnetic therapy, acupuncture, muscle relaxants, anti-inflammatory and analgesic medications, electrotherapies, advice,(4) manual therapies, prescribed exercise, and low level laser therapy (5) each with varying levels of evidence of effectiveness.

Acupuncture has been used for centuries in Traditional Chinese Medicine (TCM) and is based on a traditional framework of meridians and energy, whilst western medical acupuncture (WMA) has been focused primarily on a neurophysiological and anatomical basis.(6) In this study, WMA is termed 'dry needling', or 'needling' in short, to distinguish WMA from TCM acupuncture. Needling as a therapy has been investigated with growing evidence for its use in the management of neck pain.(7,8) These studies primarily use pain, disability and functional performance as outcome measures, however, few studies have specifically investigated the active range of motion elements contributing to functional performance. These active motion elements are rotation, flexion, extension and side bending and are often assessed within a clinical setting as a form of outcome measure for therapeutic intervention.(9) Neck rotation is of particular interest in this study as it is a major component of activities of daily living such as driving a vehicle and visual scanning of the local environment.

There is strong consensus regarding muscles involved in neck rotation, however, the involvement of levator scapulae in neck rotation has been variably reported. Standard anatomy texts do not include it in the survey of neck muscles.(10,11) The attachment of levator scapulae to the upper cervical spine is well described, although there are varying views on the role of levator scapulae in neck rotation

and ranges from having no effect on neck rotation (12) to performing an assistive role.(13)

There are several needling methods used in the management of neck dysfunction. One WMA needling method is myofascial trigger point needling with injection of lignocaine followed by “cold spray and stretch”.(14) There is evidence that dry needling myofascial trigger points alone has a similar effect on myofascial trigger points with or without the injection of any substance.(15) Dry needling of motor points within the muscle combined with needling the associated paraspinal level,(16,17) superficial dry needling,(18,19) or needle electrical intramuscular stimulation (20) are all considered methods used within the WMA framework. Regardless of the method, there appears to be a lack of research investigating the effect of dry needling on neck range of motion.

The aim of this study was to evaluate the immediate effects of dry needling levator scapulae on the range of neck rotation. The objectives were to: 1) determine any effect on neck rotation from needling levator scapulae at a specific location; and 2) consider if ~~subcategorisationsub-categorisation~~ by pain and dysfunction ~~to can determine predict~~ the effect of needling on neck rotation.

# Methods

## Design

A within participant pre-post intervention design was used in this study. An outline of process flow for the study is shown in Figure 1.

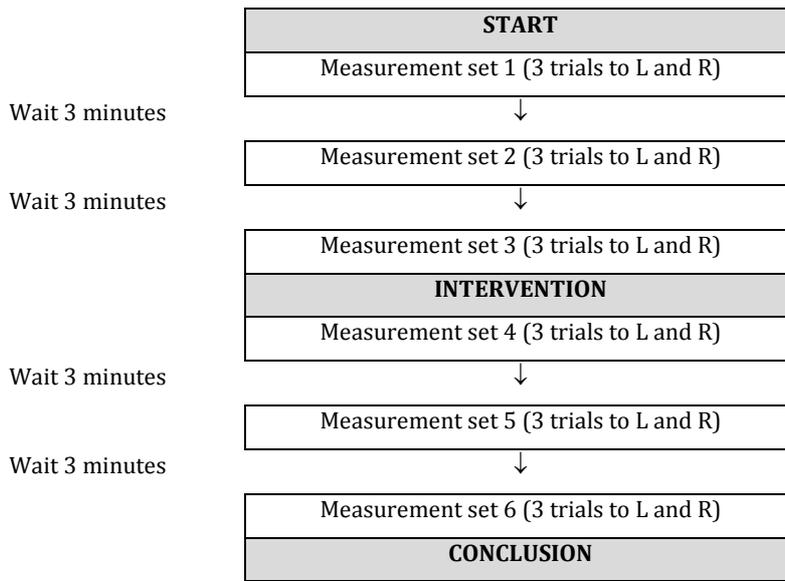


Figure 1 Process flow for the intervention study

## Recruitment

Participants were recruited by advertisements posted on campus notice boards, student clinic notice boards and word of mouth. A group sequential approach to sampling was employed where an initial sample of  $n=30$  participants were recruited and the observed effect size for the main contrast (pre vs post rotation ROM) was then ~~estimated~~ calculated for the purpose of more accurately estimating the minimum sample size required to achieve a minimum power of 0.8.

## Inclusion criteria

Participants were included if they were o: ~~O~~ver 18 years of age and could understand instructions in English. For inclusion of the participants data for analysis, the participants had to satisfy the following criteria: Presence of a taut

band within levator scapulae when examined by principal investigator prior to intervention; exhibit at least one muscle twitch response during intervention

### **Exclusion criteria**

Needle phobia; reluctance to participate in needling intervention; skin lesion at the proposed needling site; cognitive deficit or difficulty with communication; inadequate cooperation; serious neurological or systemic disorder; previous adverse reaction to acupuncture.

### **Role of personnel**

The principal investigator (YJT) was a registered physiotherapist with 8-years clinical experience and 6-years clinical experience of dry needling. The principal investigator performed all dry needling procedures. Two research assistants helped with data collection. Both assistants were in their final year of the Master of Osteopathy program, and were fully briefed about the procedures. All verbal instructions to participants were scripted to as to promote consistent performance.

### **Ethics**

All procedures were approved and ethics approval granted by the Unitec Research Ethics Committee (UREC Approval No.: 2011-1216) prior to the recruitment of participants. All participants gave written informed consent prior to participating.

### **Measurement procedures**

Neck rotation was measured in degrees using an electrogoniometer (Software: iSetSquare v1.3 on iOS; <http://www.plaincode.com>) that recorded a measurement based on a preset level of movement sensitivity for the stationary end of range. Information regarding self-reported pain intensity was gathered on a standard 100mm visual analogue scale (VAS) (21) which has been shown to be both valid and reliable.(22–24)

Each participant was seated in a stable chair and arms and trunk were secured to the chair using restraints to minimise scapular movement. The electrogoniometer was firmly mounted by hook and loop fastening tape on a helmet and secured to the participant's head. A neutral 'zero' position was established using a laser pointer mounted on the helmet. Prior to the intervention measurements of baseline ROM was undertaken (see Figure 1). For each rotation, the participant was requested to rotate within pain tolerance and with equal effort throughout the study until the electrogoniometer produced an audible "beep" indicating the terminal angle had been established. On commencement of data collection, the participant was instructed to "turn to the left". After the beep sounded, the participant was instructed to "return to the front" to the pre-established neutral guided by the laser pointer. This sequence was repeated to the left three times, then subsequently to the right three times followed by a three-minute rest interval in between sets. Each set was repeated three times prior to intervention. Levator scapulae was palpated on the side of reduced range of motion for a taut band. If range of motion was symmetrical, clinical judgement was used to determine the side with the most taut band. This taut band was palpated in a line extending towards the superior medial angle of the scapulae (insertion of levator scapulae) to confirm the muscle as levator scapulae. The needling location was established as a point in the line of the taut band 1cm from the osseous insertion onto the scapulae. Only one side was needled and this was recorded for later analysis. After intervention the same sequence of measurement was performed to obtain post intervention measures.

### **Intervention**

WMA dry needling was performed with single use, manufacturer sterilized acupuncture needles (Type: 'painfree'; dimensions 0.25x40mm; Suzhou Shenlong Medical Apparatus Co. Ltd). Each needle was disposed after a single use. Only one needle insertion was performed on each participant.

The established location was needled and manually manipulated up and down, without rotation, without withdrawal, in order to elicit the muscle twitch response. The end point for cessation of needling was established when no further twitch response could be elicited and the investigator perceived there was less of a taut band in levator scapulae. No other intervention was administered.

As far as possible information regarding the intervention was provided according to the revised guidelines for reporting acupuncture intervention.(25)

## Data management and analysis

### Measurement error

Measurement error for rotation ROM was calculated from repeated measurement (3 sets of 3 repetitions in both left and right directions). The reliability of repeated measures calculated was excellent (ICC = 0.97; 95% CI = 0.95 to 0.98) and the Typical Error = 2.07° (95% CI = 1.78 to 2.47). Measurement error calculations were made using a customised spreadsheet.(26)

### Analysis of data

Inclusion of data for analysis was dependent on the presence of a taut band detectable by the investigator and for there to be a muscle twitch response during needling. Raw data ~~was~~ were tabulated in a spreadsheet. Statistical analysis was performed using [www.ebiostatistics.com](http://www.ebiostatistics.com) and Statistical Package for the Social Sciences version 19.0 (SPSS Inc, Chicago, Illinois). Assumptions of normality were satisfied by exploring raw data using visual inspection of histograms, P-P and Q-Q plots, skewness and kurtosis, and the Shapiro-Wilk statistic as described by Field.(27) The mean values from rotation measures were used for subsequent statistical analysis. Change of ROM was the difference between pre-intervention and post-intervention ROM in degrees. The main contrast between pre- and post-measures were performed using a paired 2-

tailed Student's t-test, and 95% confidence intervals for mean differences were constructed. Power calculations were undertaken using G\*Power (v.3.1.3).(28) Values in the text are presented as mean  $\pm$  SD.

### **Categorisation**

Participants were categorised according to their reported experience of pain and measured neck rotation range of motion. This resulted in the categorisation as described in Table 1. Participants were categorised in the “no pain” category if they scored 0 on the VAS for pain intensity, otherwise they were categorised in the “pain” category. If neck rotation had a difference of greater than measurement error ( $2.07^\circ$ ) they were categorised as “dysfunctional”, otherwise they were categorised as “functional”.

**Table 1 Categorisation of pain and dysfunction presentation**

	No pain (N)	Pain (P)
Functional (F)	Category 1. No pain Functional	Category 2. Pain Functional
Dysfunctional (D)	Category 3. No pain Dysfunctional	Category 4. Pain Dysfunctional

## Results

### Participant demographic

31 participants were included in this study (n=19 male and 12 female) with a mean age of  $31.7 \pm 9.96$  years. Data from all participants was included in the analysis.

### Descriptive analysis

Pre-intervention mean ROM to the left was  $63.2^\circ \pm 12.75^\circ$  and to the right was  $64.5^\circ \pm 13.39^\circ$ . Results are consistent with mean values reported for a similar age group using similar goniometric measurements.(29,30)

### Categorisation of participants

Participants were subcategorised according to their self-reported pain intensity and objective measurements of neck ROM. From the study sample (n=31), participants were categorised under 'no pain and functional' (n=8), 'pain and functional' (n=4), 'no pain and dysfunctional' (n=7), and 'pain and dysfunctional' (n=12).

### Sidedness of needling

After assessment for restriction of neck range of motion, needling was performed on the left (n=15) or right (n=16) side. There appears to be an equal distribution for the side of restricted range of motion and hence side of needling.

### Analysis of pooled data

Pre-intervention mean ROM to the left was  $63.18^{\circ} \pm 12.75^{\circ}$  and increased to  $64.27^{\circ} \pm 11.43^{\circ}$  after intervention. The mean difference of  $1.09^{\circ}$  was not found to be statistically significant (95% CI mean difference =  $-0.25^{\circ}$  to  $2.44^{\circ}$ , 2-tailed Student's *t* test,  $t = -1.66$ ;  $df = 30$ ;  $P = 0.108$ ) although had insufficient statistical power ( $1-\beta = 0.077$ ) to rule out a Type II error.

Pre-intervention right rotation ROM was found to have a mean of  $64.48^{\circ} \pm 13.39^{\circ}$ . Post-intervention right rotation mean increased to  $67.08^{\circ} \pm 12.36^{\circ}$ . The difference of  $2.60^{\circ}$  between means was statistically significant (95% CI =  $1.06^{\circ}$  to  $4.15^{\circ}$ , two tailed Student's *t* test,  $t = -3.44$ ;  $df = 30$ ;  $P = 0.002$ ).

### Analysis of pooled data by category

There was no significant difference pre and post intervention detected for any of the subcategories for either left or right rotation. (See Table 2).

**Table 2 Results for paired t-test for pooled ROM to left and right sides**

Category	Side	Paired difference between pre and post				<i>t</i>	df	P-value <sup>1</sup>	Observed Power (1-β)
		Mean Difference	SD	95% CI of the mean difference					
				Lower	Upper				
Cat 1	Left	0.34	3.79	-2.82	3.51	-0.26	7	0.81	0.051
	Right	3.39	4.91	-0.72	7.50	-1.95	7	0.092	0.098
Cat 2	Left	1.64	4.14	-4.94	8.23	-0.79	3	0.49	0.052
	Right	3.21	4.31	-3.64	10.06	-1.49	3	0.23	0.059
Cat 3	Left	0.98	5.42	-4.03	5.99	-0.48	6	0.65	0.069
	Right	2.80	4.23	-1.12	6.71	-1.75	6	0.13	0.079
Cat 4	Left	1.47	2.49	-0.11	3.05	-2.05	11	0.065	0.067
	Right	1.77	4.10	-0.83	4.37	-1.50	11	0.16	0.067

1. p value for Student's t-test paired 2-tailed analysis. SD = standard deviation

### Analysis of data relative to side of needling

Pre-intervention mean rotation ROM to side of needling (ipsilateral) was  $60.71^{\circ} \pm 12.81^{\circ}$ . Post-intervention ipsilateral rotation mean increased to  $63.41^{\circ} \pm 11.55^{\circ}$ . The mean difference between pre and post-intervention ROM of  $2.71^{\circ}$  was statistically significant (95% CI mean difference =  $1.12^{\circ}$  to  $4.29^{\circ}$ ; Student's  $t = -3.49$ ;  $df = 30$ ;  $p = 0.002$ ).

Pre-intervention mean rotation ROM contralateral to the side of needling was  $66.95^{\circ} \pm 12.59^{\circ}$ . Post-intervention contralateral rotation mean increased to  $67.94^{\circ} \pm 11.98^{\circ}$ . The mean difference between pre- and post-intervention of  $0.99^{\circ}$  was not statistically significant (95% CI mean difference =  $-0.29^{\circ}$  to  $2.27^{\circ}$ ; Student's  $t = -1.58$ ;  $df = 30$ ;  $p = 0.13$ ). However the associated statistical power ( $1-\beta = 0.072$ ) is insufficient to definitively conclude there is no difference between pre and post measures.

### Analysis of data by relative side of response and subcategory

Paired t-test analysis was performed after participants were sub-categorised according to their reported pain and observed dysfunction. Results of paired

Student's t-test for ROM to ipsilateral and contralateral side are reported in Table 3.

**Table 3 Results for paired t-test for ROM ipsilateral and contralateral to side of needling**

Category	Side	Paired difference between pre and post				<i>t</i>	df	P-value <sup>1</sup>	Observed Power (1-β)
		Mean Difference	SD	95% CI of the mean difference					
				Lower	Upper				
Cat 1	Ipsi	2.86	5.17	-1.46	7.18	-1.57	7	0.16	0.084
	Contra	0.87	3.85	-2.35	4.08	-0.64	7	0.54	0.053
Cat 2	Ipsi	1.64	4.14	-4.94	8.23	-0.80	3	0.49	0.052
	Contra	3.21	4.30	-3.64	10.06	-1.49	3	0.23	0.059
Cat 3	Ipsi	3.85	4.34	-0.16	7.87	-2.35	6	0.057	0.15
	Contra	-0.073	4.62	-4.35	4.20	-0.042	6	0.97	0.05
Cat 4	Ipsi	2.29	4.18	-0.36	4.95	-1.90	11	0.084	0.097
	Contra	0.94	2.13	-0.41	2.30	-1.53	11	0.15	0.057

\* p value for Student's t-test paired 2 tailed analysis. SD = standard deviation

### Analysis of combined rotation range of motion data

The pre-intervention mean total rotation ROM was 127.66°±24.88°. Post-intervention total rotation mean increased to 131.35°±22.80°. The increase of 3.70° between means was found to be statistically significant (95% CI mean difference = 1.12° to 6.27°; Student's *t* = -2.93; df = 30; *p* = 0.006).

# Discussion

## OVERVIEW

Neck pain and dysfunction [is-are](#) common in the general population and dry needling may be a useful intervention for neck dysfunction. The aim of this study was to assess the immediate effects of dry needling levator scapulae on neck rotation range of motion. The main finding of this study is that dry needling appears to have a significant effect on increasing neck rotation ROM when a taut, tender to palpate levator scapulae is needled. Specifically, the dry needling of levator scapulae significantly improves rotation to the same side as that needled but does not significantly change ROM on the side contralateral to that needled.

### Improvement of neck rotation with needling levator scapulae

This study suggests dry needling of levator scapulae can improve neck rotation range of motion. This finding is broadly consistent with previous studies reporting that needling can increase neck ROM.(15,17,20,31) However, due to the differing conventions of reporting results in each of these studies, it is difficult to compare the magnitude of change between studies. A further confounder in making comparisons with other studies is heterogeneity in the styles of needling between studies. Within a WMA approach, methods that have demonstrated increases in neck range of motion are deep dry needling,(15,31) deep dry needling with additional paraspinal needling,(17) and needling with electrical stimulation.(20) This study used deep dry needling only and the needling method was similar to that performed by other deep dry needling studies.(15,17,31) With regards to the location needled, the current study needled levator scapulae at a single well-defined point. Other dry needling studies reported needling one location in the upper trapezius muscle,(15,17) or a group of muscles in the neck (31) and also found improvement in neck range of motion. Improvements were also found with needling either upper trapezius or levator scapulae with the addition of electrical stimulation.(20) This study found dry needling levator scapulae improved rotation range of motion.

No obvious reason from the data gathered from this study explains why right rotation has significant increase in ROM and not to the left. A possible explanation may be handedness but no data was collected to analyse for this.

#### **Ipsilateral improvement to side of needling**

In previous studies the specific response of range of motion in relation to the side of needling has not been reported. Studies either reported pooled left and right neck rotation ROM data,(17,31) reported ROM to both sides but did not specify side of needling,(20) or reported response on the side needled but not to the opposite side.(15) In contrast this study recorded the side of needling and the changes in neck rotation to both the left and right sides. This more complete reporting allows for analysis of the relationship between the side of needling and direction of ROM change.

#### **Clinically significant improvement**

Although this study shows statistical improvement in neck rotation ROM, the clinical significance of this change is unclear. Previous studies have reported significant immediate improvements in ROM from  $35.7^{\circ} \pm 15.3^{\circ}$  to  $60.3^{\circ} \pm 9.9^{\circ}$  ( $p < 0.05$ ) for lateral bending (15) and an increase in  $1.7^{\circ} \pm 1.5^{\circ}$  ( $p = 0.014$ ) for pooled total neck measurement.(31) Other studies reported serial improvement in ROM over 28 days from  $136.11^{\circ} \pm 17.70^{\circ}$  to  $148.06^{\circ} \pm 18.08^{\circ}$  ( $p = 0.012$ ) for total neck rotation.(17) Another study reported ROM changes from  $64.60^{\circ} \pm 11.12^{\circ}$  to  $68.33^{\circ} \pm 13.84^{\circ}$  ( $p = 0.039$ ) for left rotation and  $63.22^{\circ} \pm 11.74^{\circ}$  to  $68.37^{\circ} \pm 11.74^{\circ}$  ( $p = 0.017$ ) for right rotation over four weeks.(20) The current study found an immediate increase from  $60.71^{\circ} \pm 12.81^{\circ}$  to  $63.41^{\circ} \pm 11.55^{\circ}$  ( $p = 0.002$ ) for neck rotation when the levator scapulae on the same side is needled. It is uncertain if this small increase in ROM sufficient for clinically relevant improvements in function, or disability, or symptom status, or if the clinician could reliably detect changes of a few degrees of rotation without use of goniometry. Notably, this study investigated changes in response to needling a single point in one session, which is not typical of routine clinical practice in which therapy is usually delivered over several sessions. It is not known if the needling had long-term

effects on neck rotation. Further study to investigate the effects of multiple treatment sessions would better reflect clinical practice.

### **Specificity of needling location**

There are several approaches to selection of needle location used in WMA needling therapy and often the specific needling location is poorly described in the literature, especially in comparison to the TCM approach towards needling where needling locations are well described. Authors reporting WMA needling techniques describe needling locations in general terms (14,32) in contrast to the TCM approach where the needle location is described in detail.(33) Travell et al (14) describe specific locations within a given muscle that should be investigated for the presence of myofascial trigger points and then directs these points are needled as appropriate. Another WMA approach suggests muscle motor points are needled with the addition of paraspinal needling of the associated spinal level.(32) With regards to the correlations of trigger points with traditional acupuncture points, there are on going debates and this continues to be a contentious topic in the literature.(34–36) In this study, the TCM acupuncture point SI14, the indications for which are “neck rigidity and inability to turn the head” (33) appears to be in a similar location as that used in this study to needle levator scapulae. Furthermore, needling levator scapulae at this location has resulted in an increase in neck ROM. Research on needling locations using functional Magnetic Resonance Imaging (fMRI) found greater stimulation of higher cortical areas when needling TCM prescribed acupuncture points compared to sham points.(37) Thus further investigations into the effects of needling TCM acupuncture locations from a WMA perspective may be interesting to determine if there is a physiological basis for certain TCM practices. Regardless of the extent to which TCM acupuncture points and other needling systems coincide, the reporting of the specific location for needling in research is important in order to improve repeatability in future research and for translation of its use within the clinical setting.

### Effect of needling on different pain and dysfunction presentations

The effect of dry needling levator scapulae in participants with different combinations of pain and dysfunction in the general population has not been studied previously. The effects of dry needling for neck pain and neck rotation range of motion has been studied by several authors.(15,17,20,31) These studies included participants with neck pain and reported on the needling effects on neck ROM. However, no studies have investigated the effects of dry needling on participants from the general population, with regards to pain, dysfunction, or combinations of both. The current study assessed the effects of needling on the different combinations of either pain or dysfunction (see Fig 2). This sub-categorisation approach may, when appropriately powered, reveal types of presentation that are more or less amenable to dry needling. Individual categories had low participant numbers, with a corresponding low statistical power. Post-hoc analysis suggests 200 participants would be required in order to achieve a minimum power of 0.80. Hence further investigation of this approach with greater participant numbers is necessary for more definitive findings about the effect of dry needling levator scapulae on neck rotation to be made.

Categorisation of presentations has been used in the investigation of pain and dysfunctions for spinal manipulation and exercise,(38-40) but to our knowledge this approach has not been attempted for needling and may be worthy of further investigation. It must be acknowledged that this system of categorisation only takes into account a simple 2x2 cross-tabulation of the presence and absence of pain and dysfunction, and the cut-points were defined in this study in a way that may not represent routine clinical practice. Therefore, the findings of the sub-categorisation should only be interpreted within these limitations. The study does, however, demonstrate this approach to analysis and further work into defining appropriate cut-points for inclusion into each sub-category should be conducted.

## INTERNAL VALIDITY

There are several limitations in this study. A potential problem arises from the investigator also performing the needling intervention. Furthermore this researcher uses dry needling on a regular basis in a clinical setting, a potential source of bias as the researcher might desire to demonstrate a positive result to validate his own practice. Attempts to control for bias included stringent standardisation of instructions, and electronic measurements to minimise human error. Nevertheless, recruitment of a clinician independent of the investigator would be a more robust approach but was not reasonable within the resource constraints of this study. Analysis of data was only performed after all data was collected to minimise potentially subtle changes in intervention effort. The needling intervention was delivered in a manner consistent with routine clinical practice in an attempt to represent some degree of realistic clinical practice within the experimental setting.

This study did not use a randomised controlled trial design. A control would require a matched group that did not receive needling intervention in the 10-minutes after pre-intervention baseline data was recorded. A problem with pre-post intervention analysis is the potential for improvements in ROM to arise from movement repetitions during measurement. A design including a control group (not receiving needling) and another group receiving sham needling would be ideal, however, the sample required would be large, especially when combined with the need for large sample when conducting analysis by sub-categorisation. Specialised sham needles have been developed and preliminary data suggests they are effective.(41)

## EXTERNAL VALIDITY

Within WMA studies, the detection of a myofascial trigger points is dependent on the detection of prerequisite characteristics, however, a recent systematic review indicates that evidence for reliably detecting myofascial trigger points is poor.(42) Instead of using pre-defined criteria for detection of a myofascial trigger point this study described the characteristics of the tissue (taut band),

and tissue response (twitch response to needling) as the criteria for inclusion in data analysis. Needling with these characteristics as prerequisites has yielded a significant response for neck rotation range of motion, however, these results should not be applied to other functional systems in the body regions such as the shoulder or elbow, and investigation into the effects of needling on ranges of movement at other body regions, such as the shoulder or elbow, would be useful.

## Conclusions

This study demonstrates that a single session of dry needling applied to a palpable taut band in levator scapulae immediately improves neck rotation to the same side only, however the clinical significance of the quantity of increase is unclear. Categorisation of participants for analysis may reveal characteristics that will suggest responsiveness to dry needling for functional changes, however this requires further investigation of subcategorisation criteria, the use of designs employing multiple control groups, and large sample sizes.

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## **Section 3: Thesis appendices**

## Appendix A- Participant information sheet



Department of Osteopathy

Unitec NZ

Carrington Rd.

Mt. Albert, Auckland

### **Information for participants**

#### **Immediate effects of dry needling on dysfunctional cervical rotation**

##### **What we are doing?**

YewJin Tan is a registered physiotherapist with 7 years full-time practice experience who is undertaking further postgraduate study to register as an osteopath. He has used dry needling on a daily basis for 5 years to help people with neck pain. However dry needling has always been used in conjunction with other techniques.

Dry needling is gaining popularity as a treatment offered by many health practitioners. This study is aimed at determining the effects of dry needling only on individuals with neck problems such as limited movement and associated pain.

This research will contribute to a growing body of scientific knowledge as to the effectiveness of dry needling when used for neck problems.

##### **Where is the study being conducted?**

The research will be conducted at the following location:

Unitec Osteopathic clinic

Entry 3, Building 41

Carrington Road, Mt Albert, Auckland

##### **What will happen?**

We will place a lightweight movement measurement device mounted on a helmet on your head to measure neck rotation. 3 measurements will be taken at 3-minute intervals to determine your current amount of neck rotation. After which the intervention will be performed followed by another 3 measurements taken at 3-minute intervals. This will give data with regards to the effects of the treatment.

### **What will you experience?**

A friendly face will greet you on arrival and you'll be lead to a private room where an assistant will take the initial measurements of you neck movements. The assistant will then leave the room and the practitioner (YewJin) will enter the room and after explaining to you what will happen, and with your consent, insert 1 single-use sterilised acupuncture needle in muscle tissue adjacent to your shoulder blade. The needle will remain in place for a few minutes. After this the practitioner will withdraw the needle and ask you to move your head around to test the movement. The practitioner will leave the room and the assistant will return to take the final 3 measurements.

With the intervention, you may experience a slight 'prick sensation' as the needle enters the skin. After this the practitioner will target the point and you will experience the *deqi* sensation that has been identified to be important for an effective treatment. This *deqi* sensation has been described as "numbing", "achy", "full". Some participants may describe the sensation as "painful" but the majority use "interesting!" or "strange". The intensity of the sensation is often related to the extent of dysfunction in the local area. For example a more intense reaction would often indicate more significant dysfunction. The sensation will be elicited until the area will not allow any further such sensation – this is likely to take a few minutes.

### **Possible temporary after effects:**

After the session, the area of needling might feel slightly achy. This is a common reaction after a dry needling treatment. This sensation may last for the rest of

the day. There is a possibility of mild bruising of at most 1cm diameter in the local area but this is uncommon.

**Very low risk of infection:**

The acupuncture needles used are all sterile single use needles. All needles are safely disposed of after use. There is a very low risk of infection. All needling will be done in accordance acupuncture best practice. The practitioner has no record of causing infection with his use of dry needling practice.

**Very low risk of needle breakage:**

In previous literature cases of needle breakage have been reported. This is considered to be very rare. The acupuncture needles used are of very high quality and have been used by the practitioner regularly for 3 years with no incidence of needles breaking.

**How we handle your personal information**

Your name and information will be kept strictly confidential. All information will be stored on a password protected computer or a locked cabinet. YewJin Tan and Robert Moran will access this information to complete the analysis. A copy of the study findings can be sent to you at the conclusion of the study if you wish – just let us know when you first attend.

**Withdrawal**

At any point of this process you do not want to participate in this study you are free to withdraw at any time.

**Contact us with any questions or comments**

Please contact us if you need any more information about the project. If you have any concerns about this research project please contact either one of us:

YewJin Tan

Tel: 027 3383 119

[yewj.tan@gmail.com](mailto:yewj.tan@gmail.com)

Rob Moran

Tel: 09 8154321 ext 8197 or 021 0739984

[rmoran@unitec.ac.nz](mailto:rmoran@unitec.ac.nz)

Thank you for your time in helping us with this research, we are always happy to answer any question you may have about this research.

**UREC REGISTRATION NUMBER: (2011.1216)**

**This study has been approved by the UNITEC Research Ethics Committee from (19.10 2011) to (19.10. 2012). If you have any complaints or reservations about the ethical conduct of this research, you may contact the Committee through the UREC Secretary (ph: 09 815-4321 ext 7248). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.**

## Appendix B: Participant consent form



### Consent Form

#### Immediate effects of dry needling on dysfunctional cervical rotation

I have seen the Information Sheet about this study. I have read and understand the information sheet given to me. I have had the opportunity to discuss any queries or concerns regarding this project with YewJin Tan and am satisfied with explanations given.

I understand that taking part in this project is my choice. I don't have to be part of this if I don't want to and I understand that I may withdraw from this study at any time prior to the time of data analysis. I also understand that withdrawing will not affect my access to any services provided by Unitec, New Zealand.

I understand that anything I say and write will be kept completely confidential and that the only persons who will know what I have said or written will be the researcher (YewJin Tan) and the supervisors. I understand that data collection will involve the provision of medical details. I have been informed that a physical examination, conducted by a qualified physiotherapist undergoing Osteopathic training will take place and that the examination will be directed at assessing my back and neck. For this assessment I am aware that I will be asked to remove outer layers of clothing above my waist. I am aware that the intervention under investigation will involve the insertion of an acupuncture needle into a location near my shoulder blade.

I understand that all the information that I give will be stored securely on a computer at Unitec for a period of 5 years and that any information reported will not identify me in any way. I give permission for the data from this study to be retained and combined with other future studies provided that my identity remains anonymous.

I understand that I can withdraw my data from the project up until two weeks after the date of data collection.

I understand that I can see the finished research document.

I have had time to consider everything and I give my consent to be a part of this project.

I know whom to contact if I have any questions or concerns about this project.

The principal researcher is:

YewJin Tan

Tel: 0273383119

**Participant Name:** .....

**Participant Signature:** ..... **Date:** .....

**Project explained by:** .....

**Signature:** ..... **Date:** .....

Thank you for participating in this research



[zombies-and-horror-movies.com](http://zombies-and-horror-movies.com)

# HAVE A NECK? WE WANT YOU!

We are conducting an efficacy study on an intervention and its effects  
on the neck.

The intervention under investigation is the application of an  
acupuncture needle into a point in the shoulder to investigate the  
immediate effects on the ability turn your neck to the left or right.

This intervention is used frequently in clinical practice and this research will give more insights with regards to the population and conditions in which it will be useful for.

If you are older than 18 years of age and have a neck you are eligible to participate in this study and your assistance will be greatly appreciated

Please contact YewJin Tan at 027 3383 119 or email:

[yewj.tan@gmail.com](mailto:yewj.tan@gmail.com) for further details.

## Appendix D: Instructions for authors manuscript submission to the British Medical Journal (BMJ) Group

### Manuscript format

[Cover letter](#)

[Title page](#)

[Manuscript format](#)

[Statistics](#)

[Style](#)

[Figures/illustrations](#)

[Tables](#)

[References](#)

[Supplementary files](#)

All material submitted is assumed to be submitted exclusively to the journal unless the contrary is stated. Submissions may be returned to the author for amendment if presented in the incorrect format. It should be in both the manuscript and the details page during submission.

Please note that only the article text (from first word of main text to the last word in reference list) will be used to typeset your article.

All other data (known as the metadata), such as article title, author names and addresses, abstract, funding (etc) statements will be taken from the fields you have filled in at submission, so you must ensure that these are up to date and accurate.

### Cover letter

Your cover letter should inform the Editor of any special considerations regarding your submission, including but not limited to:

1. Details of related papers published or submitted for publication.
  - Copies of related papers should be submitted as “Supplementary files not for review” to help the Editor decide how to handle the matter.
2. Details of previous reviews of the submitted article.
  - The previous Editor's and reviewers' comments should be submitted as Supplementary material along with your responses to those comments. Editors encourage authors to submit these previous communications - doing so may expedite the review process.
3. Indication as to whether any of your article (for example, appendices, large tables) could be published as Web only files rather than in the print version of the article. Please label any files for online publication only with this designation.

### **Title page**

The title page **must** contain the following information:

1. Title of the article.
2. Full name, postal address, e-mail, telephone and fax numbers of the corresponding author.
3. Full names, departments, institutions, city and country of all co-authors.
4. Up to five keywords or phrases suitable for use in an index (it is recommended to use [MeSH](#) terms).
5. Word count - excluding title page, abstract, references, figures and tables.

### **Acceptance**

Please note: If any of this information is repeated in the final Word document it will be removed by the typesetters and replaced with the information from the submission system. Therefore please check the metadata on ScholarOne Manuscripts carefully and make any changes before submitting the final version of your Word document.

### **List of the information taken from submission system only:**

- Article type
- Title
- Author names
- Author affiliations, and corresponding author's full details
- Abstract (where applicable)
- Keywords
- Study approval
- Patient consent
- Funding statement
- Competing interests
- Contributor statement
- Trial Registration number (for clinical trials)

### **Manuscript format**

Please note, this instruction is for submission only.

**The manuscript must be submitted in Word. PDF format is not accepted.**

The manuscript must be presented in the following order:

1. **Title page.**
2. **Abstract** (or summary for case reports) (note: references not allowed in abstracts or summaries).
3. **Main text** (provide appropriate headings and subheadings as in the journal. We use the following hierarchy: **BOLD CAPS**, **bold lower case**, Plain text, *Italics*).
4. **Tables** should be in the same format as your article (ie Word) and not another format embedded into the document. They should be placed where the table is cited and they must be cited in the main text in numerical order.

## 5. Acknowledgments, Competing interests, Funding.

## 6. Reference list.

**Appendices** (these should be Web only files to save space in the print journal; if so, please ensure you upload appendices as Web Only files and ensure they are cited in the main text as such.)

**Images** must be uploaded as separate files (view further details in Figures/illustrations) All images must be cited within the main text in numerical order.

Do not use the automatic formatting features of your word processor such as endnotes, footnotes, headers, footers, boxes etc. Please remove any hidden text.

### Statistics

Statistical analyses must explain the methods used.

[Guidelines on presenting statistics.](#)

[Guidelines on RCTs: CONSORT, QUORUM, MOOSE, STARD, and Economic submissions.](#)

### Style

Abbreviations and symbols must be standard and SI units used throughout except for blood pressure values which are reported in mm Hg.

Whenever possible, drugs should be given their approved generic name. Where a proprietary (brand) name is used, it should begin with a capital letter.

Acronyms should be used sparingly and fully explained when first used.

[View more detailed style guidelines >>](#)

### Figures/illustrations

Colour images and charges

If you wish to publish colour figures in print you will be charged a fee that will cover the cost of printing. The journal charges authors for the cost of reproducing colour images on all unsolicited articles, see the journal web pages for cost information. Alternatively, authors are encouraged to supply colour illustrations for online colour publication and black and white publication in the print. This is offered at no charge.

[View more detailed guidance on figure preparation >>](#)

### File type

Ideally, submit your figures in TIFF or EPS format. We can also accept figure files of the following types: BMP, EPI, GIF, JPEG, PNG, PNG8, PNG24, PNG32, PS, PSD, SVG, WMF.

Resolution requirements apply (9cm across for single column, 18cm for double column):

1. For B/W, the format should be either TIFF or EPS. The resolution should be in 300 DPI.
2. For 4-colour, the format should be either tiff or eps in CMYK. The resolution should be 300 DPI.
3. For line-art, vector format is preferable. Otherwise, the resolution should be 1200 DPI.

During submission, when you upload the figure files label them with the correct **File Designation**: for example Mono Image, for black and white figures, and Colour Image for colour figures.

Histograms should be presented in a simple, two-dimensional format, with no background grid. Figures are checked using automated quality control and if they are below standard you will be alerted and provided with suggestions in order to improve the quality.

All images should be mentioned in the text in **numerical order** and figure legends should be listed at the end of the manuscript.

Please ensure that any specific patient/hospital details are removed or blacked out.

NOTE: we do NOT accept figures which use a black bar to obscure a patient's identity.

### **Online only material**

Additional figures and tables, methodology, references, raw data, etc may be published online only to link with the printed article. If your paper exceeds the word count you should consider if any of the article could be published online only as a "data supplement". These files will not be copyedited or typeset.

All data supplement files should be uploaded using the File Designation: "Web only files".

Please ensure any data supplement files are cited within the text of the article.

### **Multimedia files**

You may submit video and other files to enhance your article (video files should be supplied as .FLV, .F4V, .Mov, .WMV, .AVI, .MP4, .MPG). When submitting video files, ensure you upload them using the File Designation "Video Files".

### **Using material already published elsewhere**

If you are using any figures, tables or videos that have already been published elsewhere you must obtain permission from the rightsholder (this is usually the publisher and not the author) to use them and add any required permission statements to the legends.

### **Tables**

Tables should be submitted in the same format as your article (Word) and not another format embedded into the document. They should appear where the table should be cited, cited in the main text and in numerical order. Please note: we **cannot** accept tables as Excel files within the manuscript.

If your table(s) is/are in Excel, copy and paste them into the manuscript file.

Tables should be self-explanatory and the data they contain must not be duplicated in the text or figures - we will request that any tables that are longer/larger than 2 pages be uploaded as web only data.

### **References**

Authors are responsible for the accuracy of cited references: these should be checked against the original documents before the paper is submitted. It is vital that the references are styled correctly so that they may be hyperlinked.

### **Citing in the text**

References must be numbered sequentially as they appear in the text. References cited in figures or tables (or in their legends and footnotes) should be numbered according to the place in the text where that table or figure is first cited. Reference numbers in the text must be inserted immediately after punctuation (with no word spacing)—for example, [6] not [6].

Where more than one reference is cited, separate by a comma—for example, [1, 4, 39]. For sequences of consecutive numbers, give the first and last number of the sequence separated by a hyphen—for example, [22-25]. References provided in this format are translated during the production process to superscript type, which act as hyperlinks from the text to the quoted references in electronic forms of the article.

Please note, if your references are not cited in order your article will be returned to you before acceptance for correct ordering.

### **Preparing the reference list**

References must be double spaced (numbered consecutively in the order in which they are mentioned in the text) in the [slightly modified] Vancouver style (see example below). Only papers published or in press should be included in the reference list. (Personal communications or unpublished data must be cited in parentheses in the text with the name(s) of the source(s) and the year. Authors should get permission from the source to cite unpublished data.)

### **References must follow the [slightly modified] Vancouver style:**

12 Surname AB, Surname CD. Article title. Journal abbreviation Year;**Vol**:Start page–End page.

Use one space only between words up to the year and then no spaces. The journal title should be in italic and abbreviated according to the style of Medline. If the journal is not listed in Medline then it should be written out in full.

Check journal abbreviations using PubMed.

List the names and initials of all authors if there are 3 or fewer; otherwise list the first 3 and add et al. (The exception is the Journal of Medical Genetics, which lists all authors.)

Example references:

### **Journal article**

13 Koziol-McLain J, Brand D, Morgan D, et al. Measuring injury risk factors: question reliability in a statewide sample. *Inj Prev* 2000;**6**:148–50.

### **Chapter in book**

14 Nagin D. General deterrence: a review of the empirical evidence. In: Blumstein A, Cohen J, Nagin D, eds. *Deterrence and Incapacitation: Estimating the Effects of Criminal Sanctions on Crime Rates*. Washington, DC: National Academy of Sciences 1978:95–139.

### **Book**

15 Howland J. *Preventing Automobile Injury: New Findings From Evaluative Research*. Dover, MA: Auburn House Publishing Company 1988:163–96.

### **Abstract/supplement**

16 Roxburgh J, Cooke RA, Deverall P, et al. Haemodynamic function of the carbomedics bileaflet prosthesis [abstract]. *Br Heart J* 1995;**73**(Suppl 2):P37.

### **Electronic citations**

Websites are referenced with their URL and access date, and as much other information as is available. Access date is important as websites can be updated and URLs change. The "date accessed" can be later than the acceptance date of the paper, and it can be just the month accessed. See the 9th edition of the AMA Manual of Style for further examples.

### **Electronic journal articles**

Morse SS. Factors in the emergency of infectious diseases. *Emerg Infect Dis* 1995 Jan-Mar;1(1). [www.cdc.gov/nciod/EID/vol1no1/morse.htm](http://www.cdc.gov/nciod/EID/vol1no1/morse.htm) (accessed 5 Jun 1998).

### **Electronic letters**

Bloggs J. Title of letter. *Journal name Online* [eLetter] Date of publication. url

eg: Krishnamoorthy KM, Dash PK. Novel approach to transseptal puncture. *Heart Online* [eLetter] 18 September 2001. <http://heart.bmj.com/cgi/eletters/86/5/e11#EL1>

[Check your citation information using PubMed.](#)

### **Digital Object Identifiers (DOIs)**

DOIs are a unique string created to identify a piece of intellectual property in an online environment; particularly useful for articles which have been published online before appearing in print (and therefore the article has not yet been assigned the traditional volume, issue and page number reference). The DOI is a permanent identifier of all versions of an article, whether raw manuscript or edited proof, online or in print. Thus the DOI should ideally be included in the citation even if you want to cite a print version of an article.

### **How to cite articles before they have appeared in print**

1. Alwick K, Vronken M, de Mos T, et al. Cardiac risk factors: prospective cohort study. *Ann Rheum Dis* Published Online First: 5 February 2004. doi:10.1136/ard.2003.001234

### **How to cite articles once they have appeared in print**

1. Vole P, Smith H, Brown N, et al. Treatments for malaria: randomised controlled trial. *Ann Rheum Dis* 2003;327:765–8 doi:10.1136/ard.2003.001234 [published Online First: 5 February 2002].

[More comprehensive guidance about DOIs.](#)

**PLEASE NOTE: RESPONSIBILITY FOR THE ACCURACY AND COMPLETENESS OF REFERENCES RESTS ENTIRELY WITH THE AUTHORS.**

### **Supplementary files**

#### **Supplementary material**

You may submit supplementary material which may support the submission and review of your article. This could include papers in press elsewhere, published articles, appendices, video clips (please see Multimedia files instructions), etc.

All supplementary material files should be uploaded using the File Designation: Supplementary material

#### **Online only material**

Additional figures and tables, methodology, references, raw data, etc may be published online only to link with the printed article. If your paper exceeds the word count you should consider if

any of the article could be published online only as a "data supplement". These files will not be copyedited or typeset.

All Appendices should be considered Online only material.

All data supplement files should be uploaded using the File Designation: Web Only files.

Please ensure any data supplement files are cited within the text of the article.

**Multimedia files**

You may submit video and other files to enhance your article (video files should be supplied as .avi, .wmv, .mov .mp4 or .H264). When submitting video files, ensure you upload them using the File Designation "Video Files".