THE EFFECTS OF MULLIGAN’S MOBILISATION WITH MOVEMENT ON SHOULDER PAIN AND DYSFUNCTION

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STATEMENT OF ORIGINALITY

This work has not previously been submitted for a degree or diploma in any university. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made in the thesis itself.

Signature

Date 31st May 2016
The aims of this thesis were to evaluate the immediate and long-term effects of Mobilisation-with-movement (MWM) in isolation and in conjunction with taping and therapeutic exercise for people with musculoskeletal shoulder pain. In addition, the thesis aimed to assess possible indicators of poor response to MWM to the shoulder. Shoulder pain is the third most common musculoskeletal problem with patients often experiencing persistent pain and dysfunction. For the majority, conservative treatment is initially recommended. Evidence supports the use of manual therapy (MT) as a beneficial component of a multimodal management approach but the literature describes a wide variety of MT interventions, often with poor descriptions of these interventions.

Mulligan’s MT concept involves the application of a manual glide to a joint being actively moved to the point of pain onset. Mulligan called this Mobilisation-with-movement (MWM). There is evidence in the form of randomised controlled trials (RCT) supporting the immediate success of MWM for reducing pain and improving range of movement (ROM) in peripheral joints such as the ankle and elbow. Additionally, Mulligan suggests tape to augment the immediate effects of MWM. Few high-quality trials have investigated the application of MWMs for the treatment of musculoskeletal shoulder pain. Research investigating the effects of MWM in the treatment of musculoskeletal shoulder pain will guide conservative management choices.

The first study of this thesis involved an RCT to investigate the immediate effects of a single session of Mulligan’s glenohumeral MWM on pain and restriction of movement in participants (n=24) with shoulder pain and dysfunction. Statistically significant and clinically meaningful improvements in both ROM and pressure pain threshold (PPT) occurred immediately post treatment with MWM compared to sham and control interventions.

While immediate positive effects were demonstrated, Mulligan claims the effects should be long lasting and if tape is applied, further benefit can be provided. A repeated measures, crossover, single-blinded RCT was conducted to evaluate the time course of effects of glenohumeral MWM versus MWM-with-tape on ROM, pain severity and PPT. Outcome measures were taken immediately pre- and post-intervention, at 24-hours and one-week follow-up. The effect of MWM alone was not long lasting - no significant
improvements in ROM were found beyond the post-intervention assessment. MWM-with-tape was superior in improving ROM immediately post-intervention, at 24-hours and at one-week follow-up. Contrary to the first RCT, there were no significant differences over time within or between interventions for PPT. These findings suggest the mechanisms underpinning the effect of MWM need further investigation.

Some participants (n=27) who were screened as suitable for inclusion in the first study, did not respond positively to glenohumeral MWM. Mulligan espouses that, if positive effects are not demonstrated immediately, the specific MWM should be abandoned in favour of another approach. With knowledge of the scapula’s contribution to shoulder elevation, a randomised cross-over trial using scapular MWM, sham and control interventions, was conducted on participants who failed to respond to glenohumeral MWM. Scapulothoracic MWM produced a statistically significant improvement in pain-free ROM in these participants but the magnitude of change was not clinically meaningful. The lack of clinically meaningful changes in outcome measures may be due to the chronicity of participants’ signs and symptoms. Factors such as central sensitisation consequent to the chronicity of their symptoms may have influenced the results but these were not investigated in this thesis. Alternatively, it may be that there is a sub-group of people who are ‘non-responders’ to MT such as MWM. Further research is warranted to determine whether individual characteristics can identify who is likely or unlikely to respond to specific treatment interventions.

Evidence supports a combination of MT and therapeutic exercise above either modality alone for the treatment of shoulder pain. There is however, little evidence of the benefit of adding MWM to exercise for chronic shoulder pain. A pilot RCT was conducted to investigate the benefit of adding glenohumeral MWM-with-tape to an exercise programme in participants with chronic musculoskeletal shoulder pain. This was to inform a priori sample size calculations for a full-scale RCT. The primary outcome measure of function using the shoulder pain and disability index (SPADI) was used to compare glenohumeral MWM-with-tape plus therapeutic exercise with exercise alone. Using SPADI and global perceived rating of improvement (GPRI) as primary outcome measures it was estimated that the conduct of a larger RCT would not be worthwhile to demonstrate any benefit of the addition of MWM-with-tape to exercise. An RCT with 110 participants in each group would demonstrate a statistically significant improvement with exercise alone versus the addition of MWM-with-tape to exercise. Improvements in secondary
outcome measures of ROM and PPT were significant in both groups. Cold and heat pain threshold (CPT and HPT) did not change in either group nor differentiate responders and non-responders, indicating that further research is also needed to identify sub-group characteristics of people with shoulder pain who do not respond to the addition of glenohumeral MWM-with-tape to an exercise programme.
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I also send my unconditional love to my children Robert, Amber and Mark. You are all wonderful and have shown me such tremendous support.

“Wisdom is not a product of schooling but of the lifelong attempt to acquire it.”

Albert Einstein
STATEMENT OF CONTRIBUTION TO JOINTLY-PUBLISHED WORK AND CONTRIBUTIONS BY OTHERS

Included in this thesis are papers in Chapters 3, 4 and 5, which are co-authored with other researchers. My contribution to each co-authored paper is outlined at the front of the relevant chapter.

Pamela Teys
PhD Candidate

PUBLICATIONS BY THE CANDIDATE RELEVANT TO THIS THESIS

The following publications have resulted from the work presented in this thesis


CONFERENCE PRESENTATIONS RELEVANT TO THIS THESIS

The following conference presentations have been delivered at national and international conferences during the candidature period.


Teys P, Collins N, Vicenzino B (2007) The effects of a manual therapy technique on pain-limited shoulders. World Physical Therapy Conference Vancouver Canada June 2\textsuperscript{nd} -6\textsuperscript{th}.

OTHER WORK PERTAINING TO THIS THESIS BUT NOT FORMING PART OF IT


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<tr>
<td>AIGL</td>
<td>Anterior inferior glenohumeral ligament</td>
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<tr>
<td>ANOVA</td>
<td>Analysis of variance</td>
</tr>
<tr>
<td>ATS</td>
<td>Advanced thermal stimulator</td>
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<tr>
<td>CPM</td>
<td>Conditioned pain modulation</td>
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<td>CPT</td>
<td>Cold pain threshold</td>
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<td>CSFI</td>
<td>Client specific functional impairment</td>
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<td>EMG</td>
<td>Electromyography</td>
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<td>EOR</td>
<td>End of range</td>
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<td>HPT</td>
<td>Heat pain threshold</td>
</tr>
<tr>
<td>ICC</td>
<td>Intra class correlation co-efficient</td>
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<tr>
<td>MT</td>
<td>Manual therapy</td>
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<tr>
<td>MWM</td>
<td>Mobilisation-with-movement</td>
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<tr>
<td>OST</td>
<td>Orthopaedic special test</td>
</tr>
<tr>
<td>PEDro</td>
<td>Physiotherapy Evidence database</td>
</tr>
<tr>
<td>PPT</td>
<td>Pressure pain threshold</td>
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<tr>
<td>PVAS</td>
<td>Pain visual analogue scale</td>
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<tr>
<td>RCT</td>
<td>Randomised controlled trial</td>
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<tr>
<td>RMPI</td>
<td>Range of motion pain index</td>
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<tr>
<td>ROM</td>
<td>Range of movement</td>
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<tr>
<td>SEM</td>
<td>Standard error of the mean</td>
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<td>SHPR</td>
<td>Supra heat pain threshold response</td>
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<td>SMD</td>
<td>Standardised mean difference</td>
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<td>SSMP</td>
<td>Shoulder symptom modification procedures</td>
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<td>SPADI</td>
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Chapter 1

Introduction
Shoulder pain is a significant problem in today’s society and accounts for as many as 23% of people who visit a general practitioner each year (Hébert et al., 2003; van der Windt et al., 1995). The American Academy of Orthopaedic Surgeons (www.aaos.org) ranks it as the third most common musculoskeletal disorder behind knee and spinal disorders with a prevalence of up to 50% in the general population (Miranda et al., 2001). The problem is not necessarily self-limiting with evidence that 40 – 50% of people who consult a general practitioner with a shoulder problem still have symptoms one year following that initial consultation (Luime et al., 2004). A lifetime prevalence has been suggested to be anywhere between 6 and 66% (Brudvig et al., 2011; Luime et al., 2004; van der Heijden et al., 1997; van der Windt et al., 1995). In the United States in the year 2000, direct costs for the treatment of shoulder pain and dysfunction totalled US$7 billion. In the Netherlands between 2001 and 2003, during the 6 months after a first consultation for shoulder pain, the mean total costs a patient generated were €689. Almost 50% of this total figure concerned indirect costs caused by sick leave from paid work (Kuijpers, van Tulder, et al., 2006). An analysis of the costs of shoulder pain in a Swedish community in 2012 showed a mean annual cost per person of €1439 (Virta et al., 2012).

Shoulder pain presents a significant problem in terms of days lost from work after an episode of pain. This problem is universal. Thirty-one million days were lost in the UK in 2015 because of musculoskeletal problems, 26% of which were due to shoulder disorders (Health and Safety Executive (HSE), 2015). People with persistent shoulder pain generated 74% of those total treatment costs (Brudvig et al., 2011).

There is little consensus about indicators that identify those who may resolve quickly compared to those likely to progress to chronicity (Bongers, 2001; Kuijpers, van Der Windt, et al., 2006; Luime et al., 2004; van der Heijden et al., 1997). Although not totally clear, some indicators of poor recovery and poor response to treatment are suggested to be the level of reported pain and severity of symptoms at initial presentation and a history of recurrent symptoms at presentation (Bongers, 2001; Chester et al., 2013; Deutscher et al., 2009; Kennedy et al., 2006). Smoking and previous trauma to the shoulder have been linked to chronic shoulder pain (Baumgarten et al., 2010; Bongers, 2001). Further investigations into effective and more targeted treatment are warranted.
The aetiology of shoulder pain is multi-factorial and a pathophysiological diagnosis is often very difficult (de Winter et al., 1999; Green, R. et al., 2008). The source of symptoms is variable and the shoulder can be either the primary or secondary source of pain (Pribicevic et al., 2010). The terminology for diagnosis of shoulder disorders can also be variable with some disorders having several different names (Vermeulen et al., 2006). These inconsistencies make treatment of people with shoulder pain challenging for the clinician.

Treatment for patients with shoulder pain includes surgical and/or conservative approaches but evidence suggests that surgery is no more effective than conservative treatment (Dorrestijn et al., 2009; Ketola et al., 2009). Conservative treatment is usually recommended for the majority in the first instance and can involve such diverse approaches as drug therapy, corticosteroid injections, electrotherapeutic modalities and physiotherapy (Brudvig et al., 2011; Camarinos & Marinko, 2009; Hay et al., 2003; Marinko et al., 2011; McClure et al., 2006; van der Windt et al., 1995). Unfortunately, inferences cannot be drawn about the effectiveness of conservative treatment because of the poor methodological quality of studies undertaken to date (Camarinos & Marinko, 2009; Green et al., 2003), and diverse treatment options investigated (Desmeules et al., 2003). One systematic review commented that physiotherapy modalities investigated included those not commonly used by physiotherapists (Desmeules et al., 2003). The most common physiotherapy modalities; therapeutic exercise and manual therapy, have some evidence to support their use in the treatment of shoulder pain (Braun et al., 2013; Camarinos & Marinko, 2009; Kuhn, 2009; Senbursa et al., 2007). From the results of a systematic review, a gold standard therapeutic exercise approach has been recommended in a conservative rehabilitation programme (Kuhn, 2009), but currently there is no consensus about the most effective MT approach to undertake. The term manual therapy also encompasses many different treatment approaches including massage, massage-with-movement, trigger point release as well as joint manipulation and mobilisations, all of which aim to relieve pain, improve restricted movement, restore function and maintain optimal body mechanics (Hakguder & Kokino, 2002). MT has been cautiously recommended to alleviate these symptoms in patients with shoulder pain (Camarinos & Marinko, 2009; Desmeules et al., 2003; Ho et al., 2009; Michener et al., 2004). There is very little information in published studies regarding the specific types of MT as well as
insufficient detail to enable replication of MT techniques in further studies (Braun et al., 2013).

One type of MT technique that can be applied reliably and has gained popularity over the past 25 years is Mulligan’s MWM (Mulligan, 2004). Clinically, MWM application has demonstrated success in reducing pain, improving pain-free ROM and promoting recovery of function in various joints of the body (Bisset et al., 2006; Collins et al., 2004; Hall et al., 2006; Paungmali, O'Leary, et al., 2003; Vicenzino et al., 2001). The MWM is purported to have:

- Positive immediate effects on pain and ROM
- Sustained effects beyond the immediate treatment
- Added benefit if tape is added
- Additional beneficial effects as a component in a multimodal treatment plan (Hing et al., 2008).

MWM involves the combination of a manual force applied by the therapist to a joint being actively moved through the available ROM to the point of pain onset (Mulligan, 2004). An advantage of MWM is its easy replication during treatment compared with other MT techniques in terms of technique application, numbers of repetitions and sets of repetitions applied. Mulligan purports it to be effective only if there is immediate relief of pain while the patient undertakes the provocative joint movement (Mulligan, 2004). Additionally, he recommends that the specific technique be abandoned if an immediate response is not observed by either the patient or the therapist (Mulligan, 2004). Research regarding positive patient response to the application of an MWM technique has primarily focused on the ankle and elbow with only a few low quality studies, in the form of two single case reports, a pilot clinical trial and one RCT that compared MWM to sham, undertaken on the shoulder (Delgado-Gil et al., 2015; DeSantis & Hasson, 2006; Djordjevic et al., 2012; Mulligan, 2003). High quality research investigating the effects of MWM on shoulder pain and dysfunction is warranted.

1.1. OVERALL AIMS OF THE THESIS

The overall aims of this thesis were to add to the scientific knowledge regarding the effects of an MT technique, Mulligan’s MWM, to the glenohumeral joint and the scapulothoracic joint. Specifically, the goals of this programme of research were to
investigate the short and long term effects of MWM, both in isolation and in combination with therapeutic exercise and taping, for people with shoulder pain and dysfunction.

The specific aims were to investigate:

- immediate effects of glenohumeral MWM on shoulder pain and ROM
- time course of effects of a single session of glenohumeral MWM
- effects of applying tape in addition to glenohumeral MWM to the shoulder
- effects of a scapulothoracic MWM on shoulder pain and ROM in those people who did not have an immediate response to the glenohumeral MWM, and finally
- comparative effectiveness of glenohumeral MWM-with-tape plus exercise to exercise alone for the management of people with chronic musculoskeletal shoulder pain and dysfunction. The aim of the pilot trial was to inform *a priori* sample size calculations for a full-scale RCT. Some outcome measures were included to identify a sub-group of participants who respond positively to glenohumeral MWM.
Chapter 2
Background
2.1. SHOULDER PAIN

Shoulder pain affects people of all ages. Incidence increases with increasing age (van der Heijden, 1999; van der Windt et al., 1995). People who work in manual occupations and those who participate in overhead sports, such as swimming and volleyball, as well as in throwing sports are particularly susceptible. Exceptionally high demands are placed on the shoulder in many sport and work activities as well as during common activities of daily living (Smith et al., 2009). Swimmers can undertake as many as 6-8 kilometres per training session 6-7 days per week which results in up to 30,000 shoulder revolutions per week (Heinlein & Cosgarea, 2010; McMaster & Troup, 1993). Overhead throwing generates compressive forces of up to 1090 N on the shoulder (Fleisig et al., 1995).

The incidence of shoulder pain is high in people whose occupations involve repetitive overhead work, or work in awkward positions, especially if this work involves sustained shoulder rotation positions, lifting heavy loads or the use of vibratory tools (Bongers, 2001; LeClerc et al., 2004; Van der Windt et al., 1996). The overhead flexion or abduction position has been linked to the onset of shoulder pain and workers in assembly lines can sustain these overhead positions for up to 8 hours per shift (Punnett & Wegman, 2004; Seaman et al., 2010). The incidence of shoulder pain in office workers is associated with prolonged, sustained forward arm position at the desk (Szeto et al., 2005), task repetitions and magnitude of loads (Bongers, 2001). People who work long hours at computers are at high risk (Bongers, 2001). The consequences of shoulder pain for an individual include a restriction of normal arm movement that results in a limitation of activities of daily living such as dressing and personal care, sleep disturbance, limited ability to work, and a reduction in ability to participate in leisure time activities and compete in sport (McMaster & Troup, 1993). Quality of life can be significantly reduced, especially in the elderly (Östör et al., 2005; Smith et al., 2009). This would suggest that further investigations into effective and more targeted treatment are warranted.

2.2. CHALLENGES WITH DIAGNOSIS

There are significant challenges in the assessment and treatment of shoulder pain. The first is the inability to make a reliable and specific diagnosis of the presenting shoulder pain condition. Rotator cuff tendinopathy and/or subacromial bursitis are the most commonly diagnosed structures as the pain source (Lewis, 2009; Lewis & Tennent, 2007). However, it is difficult to specify exactly which structure is the source of pain
(Clark & Harryman, 1992; Lewis, 2009). The rotator cuff muscles and subacromial bursa are not distinct structures but are in fact blended together and difficult to separate (Clark & Harryman, 1992). The bursal tissue is highly innervated and would almost certainly contribute to the pain presentation (Ide et al., 1996; Vangsness et al., 1995). The reliability of putting a structural diagnostic label on a shoulder condition is poor (de Winter et al., 1999; Schellingerhout et al., 2008). There are more than 50 orthopaedic special tests (OSTs) that have traditionally been used in attempts to identify the exact structure in the shoulder that may be the source of pain (Hegedus et al., 2008; Hegedus et al., 2012; Lewis & Tennent, 2007). These tests have either high sensitivity or specificity and either clear positive or negative likelihood ratios but not both, for the specific shoulder pathology tested (Alqunaee et al., 2012; de Winter et al., 1999; Hegedus et al., 2008; Hegedus et al., 2012; Hughes et al., 2008; Snyder, 2009). Various diagnostic labels for shoulder pain conditions exist but there is a lack of uniformity in the criteria used for labelling shoulder complaints (de Winter et al., 1999; Schellingerhout et al., 2008). There is no consistency in the inclusion of specific tests for specific shoulder pain diagnoses (Hanchard et al., 2005; Lewis & Tennent, 2007; Schellingerhout et al., 2008). Sensitivity and specificity does increase when the number of tests used in combination is increased. (Çalış et al., 2000; Lewis & Tennent, 2007). Çalış et al. (2000) found that a combination of Neer’s end of range flexion and Hawkins Kennedy tests had greater predictive value for SIS (Çalış et al., 2000).

Other factors such as hypersensitivity can play a role in chronic shoulder pain contributing to difficulty with a structural diagnosis for that shoulder pain. If patients have had shoulder pain for longer than 3 months they may have elements of central sensitisation that make diagnosis of a specific structure as the source of that pain difficult (Woolf, 2011). Central sensitization of pain is defined as "an increased responsiveness of nociceptive neurons in the central nervous system to their normal or subthreshold afferent input" (Jesperson et al 2012). Clinically, this results in increased pain sensitivity in the affected area, spreading of the pain/hyperalgesia to neighbouring areas and spontaneous pain.

Comment must also be made of the presence subacromial pathology in the absence of symptoms (Frost et al., 1999; Miniaci et al., 2002). There is a lack of correlation between radiological evidence of pathology and patient symptoms (Milgrom et al., 1995). Radiological signs may be merely age related change in the tissue (Lewis, 2009). Suggestions have been made that the use of diagnostic labelling of shoulder disorders be
abandoned in favour of sub-grouping patients in terms of prognosis and response to treatment (Schellingerhout et al., 2008; Walmsley et al., 2009).

Diagnosis of SIS has, to date been based on the patient history and physical assessment using a variety of orthopaedic special tests (OSTs) to identify the underlying structures generating the pain (Hegedus et al., 2008; Hegedus et al., 2012; Lewis & Tennent, 2007). More recently, SIS has been labelled more as a syndrome or a clinical hypothesis with a broad description of it as shoulder pain that causes a limitation of movement and function (Lewis, 2011; Schellingerhout et al., 2008).

Based on this information, inclusion criteria for participants in the studies carried out as part of this thesis were not based on a specific structural diagnosis. Participants broadly fit the clinical hypothesis of shoulder impingement syndrome; i.e. suffered shoulder pain and painful restriction of movement as well as testing positive to the pain provocation tests of Neer’s and Hawkins Kennedy tests and with palpable tenderness over the anterolateral aspect of the affected shoulder (Çalış et al., 2000; Lewis & Tennent, 2007; Schellingerhout et al., 2008) A conservative approach to management could be planned based on response of the pain provocation tests to an intervention such as Mulligan’s MWM, rather than on a pathological diagnostic classification for which there is little or no reliable support.

2.3. SUSCEPTIBILITY OF THE SHOULDER TO INJURY

The shoulder has many features that make it particularly susceptible to pain and injury. The anatomy of the shoulder girdle is unique; it is potentially the most unstable joint in the body but the one with the greatest amount of movement, enabling the correct positioning of the upper limb for functional tasks (Vermeulen et al., 2006). Postural anomalies such as forward head posture, shoulder height and scapular rotation can disrupt the biomechanics of this joint complex, placing greater strain on the supporting structures of the shoulder (Greenfield et al., 1995; Milgrom et al., 1995). Shoulder muscle fatigue (Chen et al., 1999; Kibler et al., 2006), loss of muscle function (Graichen et al., 1999; Teyhen.D. et al., 2008), shoulder joint capsulo-ligamentous damage (Mihata et al., 2004; von Eisenhart-Rothe et al., 2010; Werner et al., 2004), and tears of the rotator cuff muscles (Parsons et al., 2002) can all contribute to shoulder pain. Furthermore, shoulder pain often progresses to a chronic state possibly resulting in changes associated with central sensitisation such as local and widespread hyperalgesia and heightened sensitivity to heat and cold which present further challenges for treatment (Woolf, 2011).
2.3.1. Anatomy of the Shoulder Girdle

The shoulder girdle consists of a series of joints that include the glenohumeral, acromioclavicular, sternoclavicular and scapulothoracic joints. These joints work synchronously to allow upper limb movement (Vermeulen et al., 2006). The shoulder complex only articulates with the axial skeleton via one of these joints – the small sternoclavicular joint (Vermeulen et al., 2006). Shoulder girdle movement is predominantly controlled by the intricate coordination of the muscles that attach it to the skeleton with the capsulo-ligamentous system surrounding and supporting the joints (Vermeulen et al., 2006). Ligaments supporting the glenohumeral joint include the anterior and posterior glenohumeral ligaments, acromio-clavicular and coraco-acromial ligaments (Donatelli, 2012). The anterior one third of the acromion of the scapula, the acromio-clavicular and coraco-clavicular ligaments form arches over the humeral head superiorly creating the subacromial and subcoracoid spaces (Donatelli, 2012). The muscles controlling glenohumeral joint movement include the rotator cuff muscles (supraspinatus, infraspinatus, subscapularis and teres minor) and the long head of biceps (Vermeulen et al., 2006). The design of the glenohumeral joint allows for the greatest range of movement in the body. The glenohumeral joint has large amplitudes of both physiological and accessory movements. The socket for the humeral head is the relatively small, shallow, lateral and slight upwardly facing glenoid fossa of the scapula (Figure 2.1). The glenoid fossa is deepened by the glenoid labrum but still accommodates only one third of the humeral head and hence provides very little stability (Figure 2.1) (Manske & Prohaska, 2010).
Lewis (2001) stated “The human shoulder has not evolved well; it has a relatively small suprascapular fossa, a laterally facing glenoid fossa and acromion, and a clavicle without a lateral upward flare. The insertional angle of the upward scapular stabilisers is similar to that of quadrupedal primates and less like our more immediate ancestors and the great apes” (Lewis et al., 2001). Overall, this unique anatomy places an enormous strain on the supporting structures of the shoulder which makes it poorly suited to perform occupational and sporting activities in elevation. The anatomical structure of the shoulder is recognised as a contributing factor to the predisposition of subacromial pathology (Lewis et al., 2001).

The subacromial space is very small but accommodates the rotator cuff tendons and the subacromial bursa. Estimates of the size of the subacromial space vary between 9 mm and 14 mm in the superior-inferior direction at 0° elevation in normal healthy shoulders (Flatow et al., 1994). There is potential to compromise the structures that lie within the subacromial space during upper limb movement and render them susceptible to injury (Graichen et al., 1999). Investigations using photogrammetry and magnetic resonant imaging (MRI) have found the subacromial space further decreases with movement, especially with abduction in the plane of the scapula (scaption) (Flatow et al., 1994; Graichen et al., 1999; Graichen et al., 2000). During scaption this space reduces in the superior-inferior direction to approximately 4.7 mm at 110° elevation. Similarly, the subcoracoid space narrows to less than 1 mm in the superior-inferior direction during scaption and slight internal rotation (Flatow et al., 1994). SIS is one of the most commonly diagnosed shoulder complaints (Michener et al., 2003; van der Windt et al., 1995). People
with SIS demonstrate decreased subacromial space compared to normal healthy shoulders (Busse et al., 2008; Graichen et al., 1999). The subacromial space can be reduced by up to 50% in patients with shoulder pain at 0° abduction and up to 68% compared with the contralateral side at 90° abduction when muscle activity is added (Busse et al., 2008; Flatow et al., 1994; Graichen et al., 1999; Graichen et al., 2000; Sperner et al., 1995; von Eisenhart-Rothe et al., 2010). The decreased space is thought to be associated with symptoms in people with shoulder impingement (Flatow et al., 1994; Graichen et al., 1999).

Greater compression of subacromial structures occurs during shoulder flexion, extension, abduction and rotation in people with shoulder pain (Hughes et al., 2012; Hyvönen et al., 2003; Shibuta et al., 1998; Yanai et al., 2006). In-vitro and in-vivo studies have demonstrated compression of at least one of the rotator cuff tendons, in particular supraspinatus, in positions of abduction in people with shoulder pain (Hughes et al., 2012; Yanai et al., 2006). Additionally, greater encroachment of the acromion towards the rotator cuff tendons occurs in people with SIS at 0° and 60° of elevation compared to people with normal asymptomatic shoulders (25% and 75% versus 14% and 21% respectively) (Shibuta et al., 1998). This increased encroachment is a suggested mechanism of pain generation in the form of tendon articular surface insult (Shibuta et al., 1998).

Furthermore, recordings of the amount of pressure in both in-vivo and in-vitro studies have identified increases in pressure in the subacromial structures with shoulder movements (Hughes et al., 2012; Hyvönen et al., 2003; Wuelker et al., 1995). All rotator cuff tendons are subjected to high compressive loads with each of the different shoulder movements (Bonutti et al., 1993; Hughes et al., 2012; Hyvönen et al., 2003; Yanai et al., 2006). Even greater compressive loads have however been found in patients with SIS both at rest and during full ranges of abduction when compared pre- to post-surgical removal of the acromion (Nordt Iii et al., 1999). It is not surprising that the structures such as the rotator cuff tendons and subacromial bursa may be vulnerable to damage when the arm is in the overhead position as well as during activities involving repeated or sustained overhead movements.

2.3.2 Kinematics of the Glenohumeral Joint
Normal pain-free movement of the upper limb is reliant upon the fine synchronisation of all the joints that comprise the articulations of the shoulder girdle (Donatelli, 2012).

In normal healthy people, the humeral head remains relatively centred within the subacromial space during shoulder elevation, predominantly through small adjustory movements along the glenoid fossa (Flatow et al., 1994). These small adjustments allow the upper extremity to function with precision and force. The humeral head is centred in both an anterior-posterior direction and a superior-inferior direction. This allows sufficient clearance for the structures housed under the acromion and coracoid processes during shoulder elevation (Deutsch et al., 1996; Graichen et al., 2000; Ludewig & Cook, 2002; Michener et al., 2003; Poppen & Walker, 1976). Although there are some slight variations, the amount of humeral head translation in normal healthy shoulders during passive shoulder elevation has been reported to be in the magnitude of 1-3 mm superiorly in the first 30° to 60° (Chen et al., 1999; Poppen & Walker, 1976). After this point in range, the humeral head is restricted to less than 1 mm of movement (Chen et al., 1999; Ludewig & Cook, 2002; Michener et al., 2003; Poppen & Walker, 1976; Thompson et al., 1996). During simulated active glenohumeral flexion, anterior movements of the humeral head have been found to be less than 3 mm (Michener et al., 2003; Thompson et al., 1996; Wuelker et al., 1994). Posterior translation has been reported to be in the magnitude of 0-1.5 mm from 60-90° and 4.5 mm in the final 90-120° phase of motion in normal healthy shoulders (Graichen et al., 2000; Ludewig & Cook, 2002; von Eisenhart-Rothe et al., 2010).

Excessive superior and/or anterior humeral head translations during shoulder elevation have consistently been reported to be associated with SIS symptoms and rotator cuff tendon degeneration since the 1970s (Deutsch et al., 1996; Graichen et al., 2001; Ludewig & Cook, 2002; Poppen & Walker, 1976; Yamaguchi et al., 2000). As early as 1976, it was found that patients with SIS had increased translation of the humeral head with shoulder elevation in various directions (Poppen & Walker, 1976). In 1996 patients with stages II and III impingement as classified by Neer had significantly increased superior translations of the humeral head along the glenoid during shoulder elevation compared with a normal population (Deutsch et al., 1996). Small but statistically significant increases in anterior translation of the humeral head during shoulder elevation have been found in a shoulder impingement population (Ludewig & Cook, 2002). It was...
postulated that the observed increase in the amount of translation, albeit small, might be enough to cause increased impingement with subsequent pain in the structures housed within an already very small space (Ludewig & Cook, 2002).

The position of the humeral head can be influenced by factors such as capsular and ligamentous changes from traumatic and atraumatic laxity and selective or global glenohumeral capsular tightening (Figure 2.1) (Malicky et al., 2002; Meister, 2000; Werner et al., 2004). Alterations to the glenohumeral capsulo-ligamentous system occur in both the younger sporting population and the older population who experience glenohumeral joint degenerative changes that affect these structures (Malicky et al., 2002; Meister, 2000; Warner et al., 1992). These alterations in the tightness or laxity of the capsule influence the available space for the humeral head to make the necessary adjustory movements to remain centred and not impinge on any of the structures within the subacromial space (Mihata et al., 2004). The subacromial space increases and allows increased movement that has the potential to allow increased anterior translation of the humeral head towards the antero-lateral acromion (Mihata et al., 2004). This increased humeral head movement can irritate soft tissues housed within the subacromial space (Muraki et al., 2012).

![Figure 2.2](image_url)

**Figure 2.2.** Glenohumeral capsule tightening contributes to anterior-superior translation of the humeral head.

The anterior inferior glenohumeral ligament (AIGL) has been confirmed as the major restraint to anterior translation of the humeral head in the overhead throwing position of the shoulder – that of abduction and external rotation (McMahon et al., 1999; Urayama et al., 2001). Numerous studies have investigated the effects of laxity of the AIGL subsequent to micro trauma. A cadaveric study reported consequences of progressive AIGL stretching with subsequent increases in length of the anterior band. This in turn

2-14
resulted in increases in anterior-posterior translations of the humeral head by as much as 30% (Mihata et al., 2004). The increase in total translation of the humeral head in the anterior and posterior directions was 5.1 mm after 30% stretching (Mihata et al., 2004). A more recent in-vivo study found shoulders with a diagnosis of either atraumatic instability and/or multidirectional instability with consequent shoulder pain symptoms demonstrated de-centering of the humeral head (greater than two times the standard deviation in the healthy volunteers) in the direction of instability during specific arm positions (von Eisenhart-Rothe et al., 2010). The consequences contribute to shoulder impingement symptoms because of the excessive unrestrained movement of the humeral head during shoulder elevation (Mihata et al., 2004). A goal of conservative treatment may be to address excessive anterior and/or superior movement of the humeral head but an optimal way to achieve this goal has not yet been identified.

The subacromial space can also diminish in size as a result of capsular tightening which may in turn prevent sufficient adjutory movement of the humeral head so that compression of soft tissue takes place (Werner et al., 2004). Tightness in the posterior capsule of the shoulder and the associated soft tissues has also been quantified in patients with shoulder impingement (Ludewig & Braman, 2011; Luime et al., 2004; Myers et al., 2006; Tyler et al., 2000). When the posterior capsule is tight, the humeral head is translated further anteriorly than normal along the glenoid. Compression of the rotator cuff tendons and subacromial bursa under the acromion is increased, thus contributing to symptoms of subacromial impingement (Figure 2.2) (Werner et al., 2004). In-vitro studies have investigated the effects of progressive capsular tightening on humeral head translation and subacromial contact in normal healthy shoulders (Harryman et al., 1990; Muraki et al., 2012; Werner et al., 2004). During abduction in normal healthy shoulders at 45⁰ and 90⁰, the humeral head moves 4.3 and 5.6 mm postero-inferiorly respectively. However, during successive capsular tightening of specific parts of the glenohumeral joint capsule the ‘obligate’ glenohumeral translations are altered in a reproducible fashion in an anterior and superior direction. The contact under the coraco-acromial arch is significantly increased, especially during flexion and internal rotation (Muraki et al., 2012; Werner et al., 2004). Studies investigating the association between shoulder internal impingement (impingement of rotator cuff tendons between humeral head and posterior superior glenoid rim) (McFarland et al., 1999) and posterior capsule tightness have demonstrated a positive response to treatment of this tightness (Myers et al., 2006). In this thesis, the concept of
applying a posterolateral glide to the glenohumeral joint while the patient actively moves that joint i.e. the application of a glenohumeral MWM may have some support in biomechanical terms. The glide may provide a slight stretch on the posterior capsule and therefore allow a posterior glide of the humeral head.

2.3.3 Kinematics of the Scapula

The scapula contains the glenoid fossa, which is the socket for humeral head articulation that provides an essential contribution to the kinematics of the shoulder. Efficient and effective upper limb movement relies on the co-ordinated interaction between the humerus and the scapula. The scapula must synchronously tilt and rotate through several planes of movement so that the glenoid remains ideally positioned for the humeral head during elevation of the upper limb. The scapula provides a potentially stable base from which the rotator cuff muscles can work as well as providing the link in the body’s kinetic chain between the axial skeleton and the upper limb (Kibler & Sciascia, 2010). There is a consistent scapular position and movement pattern during arm elevation in individuals with no evidence of shoulder pain or dysfunction (Ludewig & Reynolds, 2009). Normal scapular movement elevates the acromion and positions the glenoid in upward rotation and posterior tilt to provide a platform to accommodate the humeral head (Flatow et al., 1994; Silva et al., 2010). If this does not occur, the subacromial space is compromised and shoulder pain and dysfunction may result. Expert clinical opinion suggests that the normal alignment of the scapula is approximately 3 inches from the midline of the thorax, between the second and seventh thoracic vertebra and parallel to the thoracic spine. The anterior scapular surface lies flat against the rib cage and is rotated 30° anterior to the frontal plane (Sahrmann, 2002; Sobush et al., 1996). The normal ratio of scapular movement to humeral movement during full arm elevation is 1:3 and involves approximately 60° upward rotation of the scapula, posterior rotation, and external rotation (Kibler & Sciascia, 2010). Similar to the glenohumeral joint the scapulothoracic joint relies solely on co-ordinated muscle function to perform all of these tasks (Kibler et al., 2012).

Scapular dyskinesis is defined as abnormal position and movement of the scapula during shoulder elevation (Kibler & Sciascia, 2010). There is significant evidence to validate an association between alterations in scapular positioning and scapular movement during arm elevation in people with symptoms of shoulder impingement (Kibler et al.,
2006; Ludewig & Reynolds, 2009; McClure et al., 2001; Ogston & Ludewig, 2007; Su et al., 2004; von Eisenhart-Rothe et al., 2010; Warner et al., 1992). These alterations in scapular position and movement have not however been found to follow a consistent aberrant pattern (von Eisenhart-Rothe et al., 2010), but rather, an inconsistent movement pattern is thought to be indicative of patients with shoulder impingement (Borstad & Ludewig, 2002; Endo et al., 2001; Lin et al., 2005; Ludewig & Cook, 2000; Ogston & Ludewig, 2007; Ratcliffe et al., 2013; Su et al., 2004; Worsley et al., 2013). Increased glenohumeral to scapulothoracic ratio with changes of scapular positioning have also been reported (von Eisenhart-Rothe et al., 2010). These findings lend support to the notion of trialling alteration /facilitation of a scapular movement that improves pain-free range of shoulder movement rather than attempting to correct one specific scapular movement in a shoulder impingement population. The response to such a manoeuvre would help to direct treatment options.

Poor positioning of the acromion and glenoid fossa of the scapula reduces the subacromial space (Ludewig & Cook, 2000; Ludewig & Reynolds, 2009; Silva et al., 2010; Solem-Bertoft et al., 1993) and can contribute to loss of rotator cuff strength (Kibler et al., 2006; Merolla et al., 2010; Tate et al., 2008). Scapular dyskinesis affects the scapula’s role as an anchor for the rotator cuff muscles that control the humeral head position by affecting the length–tension relationships and strength of these muscles. The fact that rotator cuff muscles attach to the scapula renders them vulnerable to changes in scapular position and movement during arm elevation. Passive alteration of scapular position during arm elevation (Kibler et al., 2006; Tate et al., 2008) and/or strengthening the scapular stabilising muscles (Merolla et al., 2010) to ultimately result in improved scapular stability and movement, lead to positive effects on shoulder pain and rotator cuff muscle strength (Kibler et al., 2006; Merolla et al., 2010; Seitz et al., 2012; Tate et al., 2008). Scapular manual facilitation such as assisted scapular retraction has been trialled in people with and without shoulder symptoms via application of the “Scapular Assistance test”. This was trialled to assess effects on supraspinatus strength with positive results (Kibler et al., 2006). The authors conclude supraspinatus strength relied on the anchoring ability of the scapula (Kibler et al., 2006). Decreased supraspinatus and infraspinatus strength is evident in athletes with scapular dyskinesis (Kibler & Sciascia, 2010). Strengthening the scapular stabilising muscles in athletes with shoulder pain and scapular dyskinesis has resulted in improved supraspinatus and infraspinatus strength and a reduction in reported shoulder
pain that was maintained at 3 months and 6 months follow-up (Merolla et al., 2010). It was postulated that improvement in strength of the two rotator cuff muscles and subsequent pain reduction was directly related to improvement in strength of the scapular stabilising muscles with consequent improved scapular control (Merolla et al., 2010). The concept of manual scapular retraction to stabilise it as a base for movement is extended with the application of a scapulothoracic MWM. The scapulothoracic MWM is performed initially to correct initial scapular position and then to facilitate the specific scapular movement that optimises pain-free shoulder elevation.

The muscles responsible for co-ordinated scapulothoracic joint movement or normal scapulohumeral rhythm are serratus anterior and the three components of trapezius. These muscles act in a force couple to control scapular upward and downward rotation as well as scapular anterior-posterior tilt and internal-external rotation (Figure 2.3) (Cools et al., 2002). Loss of strength or change in activation patterns of one or more of these scapular muscles impact on the force couple required to control the co-ordinated scapular movement during shoulder elevation (Cools et al., 2002).

![Figure 2.3](image)

**Figure 2.3.** Axio-scapular muscles position and move the scapula for humeral head movement.

Evidence supports an association between strength deficits in the scapular muscles, poor control of scapular movement and alterations in scapulohumeral rhythm (Diederichsen et al., 2009; Ludewig & Cook, 2000; McMahon et al., 1996; McQuade et
al., 1998; Phadke & Ludewig, 2013). Comparative muscle strength deficits have been identified in both the scapular stabilising muscles and the rotator cuff muscles between a population of athletes with symptomatic shoulder anterior instability and a group of age matched normal healthy athletes (McMahon et al., 1996). Significantly less electromyographic (EMG) activity was found in serratus anterior in planes of scaption, abduction and flexion in the symptomatic instability group compared with the normal healthy group (McMahon et al., 1996). People with shoulder impingement have demonstrated decreased activity in serratus anterior and some components of trapezius during shoulder movements including abduction and external rotation (Diederichsen et al., 2009; Ludewig & Cook, 2000; Phadke & Ludewig, 2013). It must be noted however that there is controversy about whether the weakness in the scapular muscles is a contributing factor to, or a consequence of shoulder pain (Falla et al., 2009; Struyf et al., 2015). Other studies have further suggested that it may not just be a strength deficit but an alteration in recruitment patterns scapular muscles that is associated with shoulder pain (Cools et al., 2002; Wadsworth & Bullock-Saxton, 1997).

These findings can be extrapolated to suggest that scapular repositioning in the form of a scapular MWM may be of value to assess its effect on painful shoulder movement; (Mulligan, 2004). If scapular repositioning relieves glenohumeral joint pain during shoulder movement this could then be introduced to facilitate a pattern of “normal” scapular movement as a treatment technique for painful shoulder movement (Hing et al., 2008). An exercise rehabilitation programme could then address any assessed strength deficits of the scapular stabilisers.

2.3.4. Effects of Rotator Cuff control

The role of the rotator cuff (RC) muscles is to actively maintain the humeral head centred within the glenoid in both an anterior-posterior and a superior-inferior direction during shoulder movement (Figure 2.4) (Chopp et al., 2010). Supraspinatus, and to some extent infraspinatus, counteract the upward vector forces generated by the deltoid during shoulder movement by providing a counter depressive downward vector force to the humeral head within the glenoid (Parsons et al., 2002). Superior migration of the humeral head in patients with subacromial impingement has been attributed to failure of the rotator cuff (Graichen et al., 1999). The co-contractive force couple of supraspinatus, infraspinatus and teres minor also helps to maintain humeral head centering in an anterior-posterior
direction within the glenoid (Figure 2.4) (Parsons et al., 2002). Weakness (Teyhen. D. et al., 2008), fatigue (Chen et al., 1999; Chopp et al., 2010), or degenerative tears (Parsons et al., 2002) in these muscles can lead to the loss of ability to perform this important function and it has been suggested that the resultant shoulder “dyssynergic muscle activity” may play an important role in the pathogenesis of shoulder pain (Graichen et al., 1999). This evidence supports the need to incorporate rehabilitation of the rotator cuff muscles in a treatment programme.

![Diagram of Rotator Cuff Muscles](image)

**Figure 2.4.** Rotator cuff muscles maintain the humeral head centred in the glenoid

### 2.4. TREATMENT OF SHOULDER PAIN

The predominant approaches to the treatment of shoulder pain disorders include surgery and conservative treatment (Van der Windt et al., 1996). Comparisons of the relative benefits of surgery versus conservative treatment for shoulder impingement have not identified any particular benefits of surgery over a conservative approach in terms of pain reduction and functional recovery (Dorrestijn et al., 2009; Lewis, 2011). Due to the higher cost of surgery and the risk of complications, recommendations are that conservative treatment should be trialled first (Coghlan et al., 2008; Saltychev et al., 2015). Surgery is often only selected if a conservative approach to management has failed (Brox et al., 1993; Lewis, 2011). Conservative treatment encompasses a wide variety of approaches such as non-steroidal anti-inflammatory drugs or corticosteroids in the form of medication or injections, electrotherapeutic modalities and physiotherapy. Although a conservative approach is the most common first line of management (van der Windt et al.,
the quality of studies that have investigated the effects of the various conservative approaches has been challenged (Camarinos & Marinko, 2009; Green et al., 2003; Kelly et al., 2010; 2014; Trampas & Kitsios, 2006). Subacromial corticosteroid injections offer a small benefit over placebo and provide only short-term relief for rotator cuff pathology (Green et al., 2003). There is also concern about the accuracy of the injections and the small if not significant risk of post-injection infection (Courtney & Fernandez-de-Las-Penas, 2011). Comparisons of the effects of corticosteroid injections and physiotherapy have found no added benefit from the addition of corticosteroids in terms of overall pain and disability measures in the long term (Crawshaw et al., 2010). Cost benefit analyses have favoured corticosteroid injection but patients undergoing physiotherapy treatments seek fewer alternative interventions compared with those who have corticosteroid injections (Hay et al., 2003). In summary, research supports a conservative approach for shoulder pain in the first instance for positive patient outcomes in terms of reduction in shoulder pain and dysfunction, and in terms of cost benefit, with fewer reported complications.

2.4.1 Physiotherapy Treatment

Physiotherapy is a common conservative approach recommended for shoulder pain (Green et al., 2003). Physiotherapy treatment is prescribed either at initial consultation with a general practitioner, post corticosteroid injection or in instances when patients are reluctant to submit to corticosteroid injections or surgery (Camarinos & Marinko, 2009; Faber et al., 2006; Ho et al., 2009; Michener et al., 2004). However, there are many physiotherapeutic modalities used with little evidence to either support or refute efficacy, making it difficult to provide clear clinical guidelines for clinicians. Electrotherapeutic agents (Green et al., 2003), therapeutic exercise (Hanratty et al., 2012) and manual therapy (Bergman et al., 2004; Brantingham et al., 2011; Camarinos & Marinko, 2009; Desmeules et al., 2003) are some of the common treatment choices for physiotherapists. Reviews investigating the effects of electrotherapeutic agents have not been positive (Faber et al., 2006; Green et al., 2003). There is no evidence to support the benefit of laser for the treatment of supraspinatus tendinitis, and no evidence to support the use of ultrasound or pulsed short wave treatment in the treatment of general shoulder pain (Green et al., 2003).

Therapeutic exercise and MT are frequently employed as physiotherapeutic interventions for shoulder pain in a clinical setting both individually and in combination
The combination of MT and therapeutic exercise has been found to be more beneficial than therapeutic exercise alone in the treatment of rotator cuff disease (Braun et al., 2013; Camarinos & Marinko, 2009; Senbursa et al., 2007). Therapeutic exercise has been defined “as the use of active or assisted exercises aimed at improving range of motion, strength, or dynamic neuromuscular control of joint motion” and MT defined as “the use of manually and/or mechanically applied movement techniques to improve joint motion and extensibility and to relieve pain.” (Desmeules et al., 2003).

2.4.1.1 Therapeutic Exercise

There is significant evidence in the form of systematic reviews and randomised controlled trials to suggest that an appropriate therapeutic exercise regime for shoulder pain and limitation of shoulder function is effective in reducing pain, improving range of motion and improving functional outcomes in this population (Cathers et al., 2011; Desmeules et al., 2003; Hanratty et al., 2012; Kelly et al., 2010; Kuhn, 2009; Michaleff & Kamper, 2013; Trampas & Kitsios, 2006; Yiasemides et al., 2011). After conducting a systematic review on the effects of therapeutic exercise on shoulder pain, one author found that, despite methodological concerns in some of the randomised controlled trials reviewed, therapeutic exercise had statistically and clinically significant effects on reduction of shoulder pain and improvement of function, but not on ROM or strength in patients with rotator cuff pathology (Kuhn, 2009). A meta-analysis conducted as recently as 2013 concluded that therapeutic exercise had significant beneficial short and long term effects on pain, patient reported function and health status plus positive short term effects on strength and quality of life in patients with subacromial impingement syndrome (Michaleff & Kamper, 2013). Consensus in reviews is that the exercise regime should focus on specific types of exercise such as postural education, scapular and rotator cuff muscle strengthening and retraining muscle balance and motor control for people with shoulder impingement (Kelly et al., 2010; Michaleff & Kamper, 2013; Michener et al., 2004; Trampas & Kitsios, 2006). Individualisation of an exercise programme based on these guidelines is advocated to address identified deficits (Bennell et al., 2010; Chen et al., 2009). This should include prescription duration to help guide treatment for people with shoulder impingement syndrome (Michaleff & Kamper, 2013; Michener et al., 2004; Trampas & Kitsios, 2006). The outcome from one systematic review suggested a ‘gold standard therapeutic exercise’
programme for patients with shoulder pain (Kuhn, 2009). It suggested that ROM exercises and flexibility should be performed daily and that strengthening exercises should be performed three times per week (Table 2.1) (Kuhn, 2009).

Table 2.1 “Gold Standard” Therapeutic Exercises

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postural correction in front of a mirror</td>
<td></td>
</tr>
<tr>
<td>Shoulder shrugs</td>
<td></td>
</tr>
<tr>
<td>Shoulder retraction</td>
<td></td>
</tr>
<tr>
<td>Active ROM in front of a mirror</td>
<td></td>
</tr>
<tr>
<td>Posterior capsule stretch</td>
<td>Hold 15 or 30 secs x 3–5 repetitions</td>
</tr>
<tr>
<td>Pectoralis minor stretch</td>
<td>Hold 15 or 30 secs x 3–5 repetitions</td>
</tr>
<tr>
<td>Seated push up / elbow push up/ push plus supine</td>
<td>3 sets 10 repetitions (60 secs interval)</td>
</tr>
<tr>
<td>Upright rows</td>
<td>3 sets 10 repetitions (60 secs interval)</td>
</tr>
<tr>
<td>Internal rotation in adduction</td>
<td>Use theraband resistance</td>
</tr>
<tr>
<td>External rotation in adduction-standing /side lying</td>
<td>Use theraband resistance</td>
</tr>
</tbody>
</table>

Some controversy however still exists. Other systematic reviews suggest that it is difficult to recommend a specific exercise programme because of the variety of exercise interventions together with the poor description of the exercise protocols within studies (Hanratty et al., 2012; Michaleff & Kamper, 2013). One systematic review carried out in 2010 aimed to focus on the effectiveness of therapeutic exercise intervention alone for the treatment of shoulder impingement but found that at least five of the studies in the review included combinations of treatment in conjunction with exercise making conclusions difficult. It was therefore postulated that the evidence for the use of therapeutic exercise in the treatment of subacromial impingement syndrome was unclear because of insufficient sample sizes, inconsistent results and poor methodological quality (Kelly et al., 2010). Based on current evidence, the fourth study in this thesis chose to recommend an individualised exercise programme based on guidelines of posture correction, scapular and rotator cuff strengthening and scapulo-humeral and glenohumeral motor control retraining.

2.4.1.2 Manual Therapy

MT techniques have been defined as “techniques that require the therapist to apply an external force to the patient to produce a desirable amount of deformation of the targeted
joint connective tissues, and a relative displacement of the bones at either end of the joint in accordance with the load–displacement relationship of the targeted tissues” (Somty, 2009). Care needs to be taken with the term “shoulder”. In some studies, this term has included MT techniques to the cervical and thoracic spine and upper ribs (Bergman et al., 2004; Brantingham et al., 2011; Somty, 2009). Evidence presented in this thesis refers to the shoulder as the glenohumeral, sternoclavicular, acromioclavicular and scapulothoracic joints and MT as joint mobilisations, soft tissue massage and stretches.

The efficacy of either MT alone or the inclusion of MT in a multimodal treatment programme for shoulder musculoskeletal pathologies has been extensively examined. Positive results have been reported in terms of mobility improvement to support the use of mobilisations of the shoulder joint compared with either no treatment (Nicholson, 1985), other non–surgical treatment (Brox et al., 1993), or treatment in conjunction with therapeutic exercise (Bang & Deyle, 2000; Bergman et al., 2004; Camarinos & Marinko, 2009; Conroy & Hayes, 1998; Dickens et al., 2005; Nicholson, 1985; van der Heijden et al., 1997). There is evidence to support the use of MT and therapeutic exercise specifically for shoulder impingement (Michener et al., 2004). Results are conflicting though, with some reports of inconclusive findings regarding the benefits of the addition of MT to an exercise programme (Brudvig et al., 2011; Chen et al., 2009; Ho et al., 2009; Trampas & Kitsios, 2006), together with reports of no clear evidence of any additional benefits of MT compared with other interventions (Ho et al., 2009). One review advised caution because of the generally low methodological quality of studies in terms of lack of blinding of both the study participants and outcome assessors, no intention to treat analysis and no concealed allocation (Brudvig et al., 2011). The trials with strong support for the inclusion of MT in a treatment programme for shoulder impingement also have not been clear with respect to the type of MT nor for an algorithm for prescription (Bang & Deyle, 2000; Brudvig et al., 2011; Conroy & Hayes, 1998). Investigations of the use of MT alone for the treatment of shoulder pain have also reported methodological flaws, including heterogeneity in outcome measures used, lack of blinding of the data collector, small numbers treated and variability in the number of treatments received (Camarinos & Marinko, 2009; Green et al., 2003; Ho et al., 2009; Kachingwe et al., 2008; Michener et al., 2004; Trampas & Kitsios, 2006). Further high quality research is needed to examine types of MT used, how the MT technique is applied in terms of prescription and total
numbers of treatments required. Long-term effects need to be assessed as well as the characteristics of people who do and do not respond to MT and therapeutic exercise.

There are many different types of MT techniques used for the treatment of shoulder pain and dysfunction. MT techniques include passive joint mobilisations such as those described by Maitland, Cyriax and Kaltemborn as well as Mulligan’s MWM (Chen et al., 2009; Djordjevic et al., 2012; Maitland, 2014; Mulligan, 2004; Winters et al., 1997). Very few studies have compared different types of MT techniques in conjunction with supervised exercise on a patient population with shoulder impingement (Kachingwe et al., 2008). In 2009 a systematic review found positive evidence for the use of MT to relieve shoulder pain in patients with shoulder impingement (Camarinos & Marinko, 2009). After finding positive evidence for the use of MT for this shoulder pain population generally, the review undertook to investigate types of MT used. It found that four different types were used in the seven studies included in the systematic review. These included MWM, the Cyriax method, and passive mobilisations performed in both the mid-range and at the end of range of a patient’s available joint movement, consistent with the Maitland approach (Camarinos & Marinko, 2009). The conclusion was that there was insufficient consistency in the MT approaches to enable identification of one preferred type of MT (Camarinos & Marinko, 2009). The only consensus was that mobilisations carried out in the mid-range of glenohumeral joint abduction were not effective for relief of pain or improvement in mobility of the shoulder joint (Kachingwe et al., 2008). Results, although not significant, demonstrated a higher percentage improvement in the MWM group for range of movement compared with exercise and low grade passive mobilisations at the end of range of movement (Kachingwe et al., 2008). The difficulty in replicating the passive joint mobilisations in future studies is the fact that most techniques have not been sufficiently described in terms of position of the joint and the grade and time of application (Bang & Deyle, 2000; Chen et al., 2009; Conroy & Hayes, 1998). A MT technique that is adequately described and has sufficient consistency in application for replication is Mulligan’s MWM (Hing et al., 2008; Mulligan, 2003).

MWM is a suite of MT techniques developed by New Zealand physiotherapist, Brian Mulligan (Mulligan, 2004). The Mulligan concept differs from the more traditional MT techniques of Maitland and Cyriax in that Mulligan advocates the application of a sustained passive accessory gliding force to a joint while the patient actively performs a functional task or movement that has been identified as problematic in the initial assessment.
The patient performs the movement to the point of pain onset. The glide should be applied close to the joint line to avoid unnecessary movement and the direction of the glide should be parallel to the joint line such that it achieves the greatest improvement in the patient’s movement. Mulligan suggests a “tweaking” of the direction of the glide to achieve the greatest effect with the least amount of force required. The problematic movement can also be passively performed by the treating therapist to the point of pain onset (Hing et al., 2008; Mulligan, 2004). MWM is effective in reducing pain and increasing ROM in other joints such as the elbow, spine and ankle (Bisset et al., 2006; Collins et al., 2004; Hall et al., 2006; Paungmali, O’Leary, et al., 2003; Souvlis et al., 2005). A significant advantage of MWM is the standardisation that can be imposed in terms of patient position, technique application to the affected joint and numbers of repetitions and sets applied per treatment session to achieve a positive effect (Vicenzino et al., 2011). The MWM application dose is relatively easy to calculate by multiplying the number of repetitions by the number of sets per session (Vicenzino et al., 2011).

One tenet of Mulligan’s techniques is that they should be used only if they provide immediate relief from pain during the treatment session (Hing et al., 2008; Mulligan, 2004; Vicenzino et al., 2011). If this does not occur, the therapist is advised to try either another MWM or abandon the technique altogether in favour of a different approach. The MWM can be integrated into the physical examination to assess its effectiveness as a treatment technique. The MWM application also provides important immediate feedback to the patient regarding the effectiveness of the technique and its reason for incorporation into the treatment plan. There is some evidence in the form of RCT’s both in vivo and in vitro, a clinical trial and single case studies to support the use of MWM to improve pain-free shoulder movement (Delgado-Gil et al., 2015; DeSantis & Hasson, 2006; Djordjevic et al., 2012; Hsu et al., 2000; Mulligan, 2003). Further high-quality RCTs are warranted to investigate immediate effects of the glenohumeral MWM in a population with shoulder impingement.

Mulligan purports that a significant clinical advantage of MWM is that the application should have a lasting effect (Mulligan, 2004). Mulligan himself reported long lasting effects from a single MWM session in a series of four shoulder pain case studies (Mulligan, 2003). Only one other study has investigated the long lasting effects of a single session of MWMs over time and found positive effects immediately post-intervention of a single session of the Mulligan MWM (bent-leg-raise technique) that were apparent at 24 hours.
hours follow-up in people with low back pain (Hall et al., 2006). One aim of this thesis therefore was to assess time effects of the glenohumeral MWM (Mulligan, 2003).

Mulligan advocates the application of tape to enhance the positive effects of MWM (Hing et al., 2008; Vicenzino et al., 2011). Tape is applied to augment the direction of applied MWM force and is usually left on the patient for a maximum of 48 hours following the application of the MWM (Hing et al., 2008; Mulligan, 2004). There is some evidence to support the advantages of application of either rigid or elastic tape to patients with shoulder impingement (Ketola et al., 2009; McConnell & McIntosh, 2009; Pogliaghi & Malgrati, 1998). The goal of tape application following glenohumeral MWM is to enhance the MWM’s effects on shoulder pain and dysfunction. Further studies to assess these possible beneficial effects in a shoulder impingement population following application of the glenohumeral MWM are needed to verify this tenet.

2.5. SUMMARY
Shoulder pain is the second most common musculoskeletal problem seen in physiotherapy practice (Bot et al., 2004). The causes of shoulder pain are multi-factorial and diagnosis is often difficult (van der Windt et al., 1995). The combination of MT and therapeutic exercise is the most common physiotherapy approach (Desmeules et al., 2003). There are evidence based guidelines for therapeutic exercises for the treatment of shoulder pain but there is a dearth of information regarding the specific types of MT and guidelines for application of MT in patients with shoulder pain (Kuijpers, van Der Windt, et al., 2006). Recommendations have included the conduct of future high quality studies with methodological consistency to enable comparisons and to identify characteristics of patients who respond to MT. Mulligan’s MWM has certain distinct advantages in that application can be consistent across patients. MWMs may be used as “treatment direction tests” to assess patient response before further application in treatment. Further research is warranted as currently there is little evidence of the effects of MWM in a shoulder pain population. There is also currently no consensus about clinical characteristics that identify patients who respond positively to MWM treatment and this too warrants further investigation.

2.6. THESIS STRUCTURE, HYPOTHESIS, AIMS AND OBJECTIVES
The primary aim of this thesis was to add to the evidence based scientific knowledge regarding the effects of two Mulligan’s MWM techniques to the glenohumeral joint and
the scapulothoracic joint; on shoulder pain and dysfunction both immediately and long term. The additional benefit of tape was also assessed. A further aim was to investigate whether the inclusion of the glenohumeral MWM added benefit in a multi modal treatment plan that included therapeutic exercise and taping in the conservative treatment of shoulder pain. Finally, the pilot trial aimed to calculate *a priori* sample size to inform the conduct of a larger full-scale RCT and to assess if the use of specific outcome measures could identify clinical characteristics of those patients who respond well to MT. This thesis does not discuss the possible mechanism of effect of the MWM in any detail.

It was hypothesised that glenohumeral MWM would provide greater positive immediate effects in terms of pain relief and improved range of movement compared to a placebo and control condition. It was hypothesised that the positive effects of a single application of glenohumeral MWM would be maintained for one week, especially if tape was added. Furthermore, for those patients who did not respond to glenohumeral MWM it was hypothesised that because of the relationship between the scapula and the glenohumeral joint a scapulothoracic MWM may provide improved pain-free range of shoulder movement. The final study was a pilot trial designed to calculate numbers required for the conduct of a larger RCT comparing exercise alone to exercise plus glenohumeral MWM-with-tape.

In this thesis, the Background Chapter synthesised current knowledge about shoulder pain. Chapters 3 and 4 are published works and Chapters 5 and 6 are due to be submitted for publication. Finally, Chapter 7 includes summary of findings, discussion and suggestions for future directions of research.

### 2.6.1 Specific Aims and Objectives

Aim (1): to assess the immediate effects of glenohumeral MWM on shoulder pain and range of movement.

*Objective 1: to perform a RCT to assess the immediate effects of a glenohumeral MWM compared with placebo and control interventions.*

A within-subjects RCT was designed to test Mulligan’s tenet that a single application of glenohumeral MWM has immediate effects on shoulder pain and dysfunction. Participants with shoulder pain and limited range of movement were randomly assigned to glenohumeral MWM, placebo or control conditions. Reported findings add support for the
use of glenohumeral MWM in this shoulder pain population. The published article is included in Chapter 3 as:


Aim (2): to assess the time course effects of glenohumeral MWM and the effects of adding tape to the shoulder after the MWM application in participants with shoulder pain.

Objective 2: to perform a cross-over study to determine if glenohumeral MWM alone versus glenohumeral MWM-with-tape maintained improvement in shoulder pain and range of movement for one week.

Mulligan espouses the effects of a single application of MWM should be long lasting. It is important for clinicians to have some knowledge of the length of time positive effects of a single application of a MT technique may last and if other interventions such as tape application will help to prolong those effects. This knowledge aids the structure and planning of a treatment programme. The aims of the cross-over study reported in Chapter 4 were to assess the time that effects of a single application of glenohumeral MWM lasted compared with glenohumeral MWM-with-tape. The results of this study are included and published as:


Aim (3): to assess if another MWM, namely a scapulothoracic MWM, had positive effects on shoulder pain and ROM in those participants who did not have an immediate response to the glenohumeral MWM.

Objective 3: to conduct a RCT to assess the effects of scapulothoracic MWM on participants who did not respond initially to glenohumeral MWM.

This study was based on Mulligan’s tenet, that a MWM technique should be abandoned if it does not have an immediate effect on signs and symptoms. The participants in this study were enrolled initially into the first study but failed to respond immediately to glenohumeral MWM in terms of improved pain free shoulder movement. Mulligan’s
tenet aligns with current research recommendations that clinicians treat according to patient response rather than according to a pathological diagnosis (Lewis & Tennent, 2007). The findings of this study are reported in Chapter 5.

Aim (4): to assess if MWM-with-tape added to an exercise programme adds benefit for participants with chronic pain-restricted shoulder movement as well as to attempt to identify outcome measures that may indicate those who are more likely to respond to MT in a trial of therapeutic exercise, Mulligan’s MWM-with-tape versus exercise alone for the management of musculoskeletal shoulder pain.

**Objective 4: to conduct a pilot RCT to compare glenohumeral MWM-with-tape and exercise versus exercise alone using the shoulder, pain and disability index (SPADI) as the primary outcome measure.**

Evidence is conflicting regarding benefits of the addition of MT to a therapeutic exercise programme. This pilot trial was undertaken to measure response to glenohumeral MWM-with-tape plus exercise versus exercise alone in a programme that incorporated four treatment sessions. This was conducted to inform a priori sample size calculations for a full-scale RCT. This pilot trial also assessed the feasibility of using quantitative sensory tests (QST) as outcome measures in a population with chronic musculoskeletal shoulder pain as evidence suggests low levels of PPT, HPT and CPT may be associated poorer outcomes in the treatment of musculoskeletal shoulder pain (Chester et al., 2013). These results are reported in Chapter 6.

Chapter 7 provides a summary and synthesis of the findings from all four studies, and suggestions for future research in this area.
Chapter 3
The initial effects of a Mulligan's MWM technique on ROM and PPT in pain-limited shoulders
STATEMENT OF CONTRIBUTION TO CO-AUTHORED PUBLISHED PAPER

This chapter includes a co-authored paper. The details of the article are:


My contribution to the paper involved: collaboration in study design, subject recruitment, collection of data, preliminary data analysis, write-up and preparation for submission.

(Signed) [Signature]

(Date) 1st June 2016

Student: Pamela Teys

(Countersigned) [Signature]

(Date)

Supervisor: Leanne Bisset
3.1. INTRODUCTION

Shoulder pain with a subsequent restriction of movement is a common problem in both the sporting and working population. Approximately 1% of adults consult a general medical practitioner with an episode of shoulder pain each year (Bridges-Wegg, 1992; Pope et al., 1997).

There is a dearth of high-quality trials that support or refute the use of physiotherapy in shoulder pain (Green et al., 2003), but there is some support for individualised programmes of MT and exercises in the treatment of shoulder impingement syndrome (Michener et al., 2004). Two trials conducted by Bang and Deyle (Bang & Deyle, 2000) and Nicholson (Nicholson, 1985), which rated six and five out of ten, respectively, on the PEDro quality rating scale (www.pedro.fhs.usyd.edu.au), reported that supervised exercise combined with MT was better than supervised exercise alone in the treatment of shoulder impingement (Bang & Deyle, 2000; Nicholson, 1985).

Mobilisation-with-movement (MWM) is a class of MT techniques that is widely used in the management of musculoskeletal pain. It involves the manual application of a sustained glide by a therapist to a joint while a concurrent movement of the joint is actively performed by the patient (Mulligan, 2004). Studies using MWM techniques on the elbow and ankle have shown them to be effective in reducing pain as measured by visual analogue scale (VAS) and pressure pain threshold (PPT) and increasing joint range of movement (ROM) (Abbott, 2001; Abbott et al., 2001; Chen et al., 1999; Collins et al., 2004; O’Brien & Vicenzino, 1998; Paungmali, O’Leary, et al., 2003; Vicenzino, B. & Wright, 1995).

During shoulder movement in participants with no pathology the humeral head remains relatively centred in the glenoid, predominantly through small translatory glides in the glenoid (Harryman et al., 1990). Earlier studies have identified that altered shoulder kinematics are associated with shoulder pain (Halder et al., 2001; Howell et al., 1988; Ludewig & Cook, 2000; Ludewig & Cook, 2002). Kinematic studies of patients with impingement, rotator cuff tears, loss of capsuloligamentous integrity or neuromuscular fatigue, have demonstrated abnormal or excessive superior and/or anterior translation of the humeral head in the glenoid fossa (Flatow et al., 1994; Fu et al., 1991; Kamkar et al., 1993). It would appear that excessive translation of the humeral head along the glenoid results in pain and functional impairment (Matsen et al., 1993). It has been suggested that the application of a posterior glide MWM to the shoulder may correct this fault and allow
optimal pain-free motion to occur (Mulligan, 2004). Hsu et al. (Hsu et al., 2000), in a study of 11 cadavers, found the application of an anterior-posterior glide towards the end of range of abduction was effective in improving the range of glenohumeral abduction (Hsu et al., 2000). To date, no studies have investigated the effects of the MWM in people with shoulder pain and reduced ROM. The aim of our study was to evaluate the effect of a MWM on shoulder ROM and PPT.

3.2. METHODS

A repeated measures, crossover, double-blinded randomised, placebo-controlled trial was conducted to evaluate the initial effects of a shoulder MWM on ROM and PPT. This design was used to reduce the effects of individual variation and strengthen internal validity.

3.2.1. Participants

Twenty-four participants (11 males and 13 females) aged between 20 and 64 years (mean 46.1 years, standard deviation 9.86) were recruited from the general population in southeast Queensland. The primary inclusion criterion was the inability to elevate the arm greater than 100° in the plane of the scapula because of the presence of pain over the anterior aspect of either shoulder. The duration of the pain had to be greater than one month to ensure that there was an established shoulder condition and for less than one year so as to limit the study population to those whose pain was not likely to be a result of such conditions as recalcitrant frozen shoulder. The main exclusion criterion was shoulder pain that was deemed not to be musculoskeletal in origin. Other exclusion criteria were any medical condition that would exclude the patient from physiotherapy treatment, active inflammatory disease, infection, cancer, neuromuscular disorders and fractures around the shoulder. The participants were also screened for involvement of the cervical spine that may have contributed to the shoulder condition and excluded if there was evidence of cervical spine referral of pain to the shoulder. A physiotherapist who holds a post-graduate sports physiotherapy degree and has greater than 15 years’ clinical experience performed all screening examinations.

Ethical clearance was obtained from the University of Queensland’s Medical Research Ethics Committee and signed informed consent was gained from all participants prior to their inclusion in the study.
3.2.2. Outcome measures (dependent variables)

The outcome measures were taken by an investigator skilled in their application and who remained blind to the allotted treatment condition. The outcome measures used were range of glenohumeral elevation in the plane of the scapula and PPT over the anterior shoulder.

3.2.2.1. Pain-free ROM in the scapular plane

A universal goniometer was used to measure the ROM in the plane of the scapula. This has been shown to demonstrate good intra-tester reliability if consistent landmarks are used (Hayes et al., 2001). The plane of the scapula is defined as 30° anterior to the coronal plane. This was calculated by aligning the axis of the goniometer along the superior aspect of the shoulder and moving one arm of the goniometer 30° forward from that frontal plane whilst the other arm of the goniometer remained in the frontal plane. The patient was then asked to move the affected arm in that plane through a small arc of movement short of pain, by aligning the arm movement to a vertical line drawn up the wall. The line on the wall was used to aid test–retest repeatability.

Goniometric measurement of elevation in the plane of the scapula was achieved by aligning the centre of the goniometer with the centre of the glenohumeral joint, one arm of the instrument along the lateral border of the scapula and the other along the humerus in line with the lateral epicondyle aided by skin markers. A measure of active ROM was taken. The participant was asked to move the arm into elevation along the plane of the scapula just to the onset of pain and this process was repeated three times. This technique was in accordance with guidelines of goniometric measurement as outlined by Moore (Gerhardt, 1993).

3.2.2.2. PPT

A quantitative measure of pain was obtained by the use of pressure pain algometry, which has demonstrated good inter- and intra-rater correlation and reliability in other studies (Pontinen, 1998).

The most sensitive point was located over the anterior aspect of the shoulder by manual palpation and marked with a permanent marker so that the same point could be used for pre- and post-condition application measures. As in previous work carried out in this laboratory (Collins et al., 2004; Paungmali, O'Leary, et al., 2003; Sterling, M et al.,
pressure was applied via a digital pressure algometer (Somedic AB, Farsta, Sweden) applied perpendicular to the skin at a rate of 40 kPa/s through a rubber-tipped probe (area 1 cm²). The patient was instructed to activate a button as soon as a change of sensation from one of pressure to one of pain was experienced (threshold of pain). This process was repeated three times with a 30-seconds rest period between each measurement.

3.2.3. Experimental conditions (independent variables)

There were two independent variables in the research design; treatment condition and time (pre-, post-application). Treatment condition had three levels, which included the MWM, a sham and a control condition. A physiotherapist who was blind to the pre- and post-outcome measures (i.e. played no part in taking the outcome measures) applied all conditions. This physiotherapist held both musculoskeletal and sports post-graduate degrees with more than 10 years’ clinical experience.

The treatment condition consisted of the application of a posterolateral glide (MWM) to the affected shoulder (Figure 3.1). The participant was seated and the therapist stood beside the participant on the opposite side to the affected shoulder. One hand was placed over the scapula posteriorly while the thenar eminence of the other hand was placed over the anterior aspect of the head of the humerus. A posterior gliding force was applied to the humeral head. The participant was then asked to raise the affected arm in the plane of the scapula to the point of pain onset while the therapist sustained the gliding force to the humeral head, with care to avoid the sensitive coracoid process. Three sets of 10 repetitions were applied with a rest interval of 30 seconds between each set. The therapist endeavoured to maintain the glide at right angles to the plane of movement throughout the entire range. The participant was instructed that the MWM procedure, including arm elevation, was to be pain-free, and must be ceased immediately if any pain was experienced during the application (Exelby, 1996; Mulligan, 2004).
Figure 3.1. The MWM technique in which the therapist applies a posterolateral glide to the humeral head along the plane of the glenohumeral joint while stabilising the scapula with the other hand.

The sham condition replicated the treatment condition except for the hand positioning. The therapist stood on the opposite side of the participant and placed one hand along the clavicle and sternum and the other on the posterior aspect of the humeral head of the affected shoulder. A simulated anterior glide was performed but with minimal pressure actually applied. The participant was asked to elevate the affected shoulder in the plane of the scapula through half of their available pain-free range to minimise the likelihood of pain provocation. The number of repetitions and sets were as per the treatment group.

In the control condition the participant was seated for the same length of time but no manual contact between the therapist and the participant took place.

3. 3. PROCEDURE

Participants were initially assessed for their suitability for inclusion in the study and underwent a physical screening of the affected shoulder and cervical spine by an experienced post-graduate sports physiotherapist with more than 15 years of clinical experience. This session was also used to familiarise the participant with the testing procedures, laboratory environment and investigators.

Participants attended three sessions at approximately the same time each day to prevent any diurnal variations in joint range and pain potentially confounding results and
with at least an intervening 24-hour interval to reduce the influence of any carry-over effect. Testing was conducted in a temperature and humidity controlled laboratory. The participants were requested to avoid factors that may influence their shoulder pain, such as analgesics and/or anti-inflammatory medication during the week of testing.

At each experimental session, following the recording of baseline measures, each participant received one of the three treatment conditions (MWM, sham, control), in a randomised order known only to the treating therapist. The treatment allocation sequence was block randomised using the drawing of lots and concealed from the investigator who took the outcome measurements. Following the application, outcome measures were again taken. Participant blinding was facilitated by recruitment of people who had no experience of the manipulative therapy techniques applied to the shoulder and by careful instruction that did not refer to the study's aims of evaluation of a treatment technique. Participants were informed that the study was investigating the effects of manual handling on shoulder pain. An exit questionnaire assessed the adequacy of patient blinding. Results of the exit questionnaire showed that three participants (12%) correctly guessed they had only received active treatment and none had correctly guessed that they had received either a sham or control.

3.4. RELIABILITY

Acceptable intra-rater reliability was determined through analysis of pre- to post-control measures of ROM and PPT. For this study the intra-class correlation coefficient (ICC$_{2,1}$) and standard error of the measurement (SEM) for ROM were estimated to be 0.98° and 1.33° respectively. The ICC$_{2,1}$ and the SEM for PPT were estimated to be 0.96 and 10.7 kPa respectively. This indicates that both the size of the error (SEM) and the ICC are indicative of reliable measures.

3.5. DATA MANAGEMENT AND ANALYSIS

Two independent variables were incorporated into the research design: treatment (MWM, sham, control) and time (pre- and post-application). Dependent variables included ROM and PPT. Prior to analysis, the average of triplicate measures of ROM and PPT were calculated.

A two-factor analysis of variance (ANOVA) and appropriate post-hoc tests of simple effects were then performed on each of the two dependent variables to test the hypothesis
that MWM produced changes in excess of sham and control from pre- to post-application (p = .05).

3.6. RESULTS

3.6.1. ROM

There was a significant Time by Condition interaction effect for ROM (F (2,46) = 16.3, p = .000) with a significant mean improvement of 16° (p = .000) pre- to post-treatment after the application of the MWM compared with 4° (p = .06) for the sham application and no change (p = .84) for the control condition (Error! Reference source not found.). The mean differences between the MWM and Sham (10°) and MWM and Control (11°) were statistically different after application; p < .02 where they were not different at baseline.
Table 3.1 The mean (95% CI) for range of movement (ROM) in degrees and pressure pain threshold (PPT) in kPa for the Mobilisation-with-Movement treatment technique (MWM), Sham (S) and Control (C). Also included are the mean differences (95% CI) between pre- and post-intervention, as well as the differences between MWM-S and MWM-C.

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<th>MWM Mean (95% CI)</th>
<th>Condition mean differences (95% CI)</th>
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<tr>
<td></td>
<td>Sham</td>
<td>Control</td>
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<tr>
<td>ROM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>102.2 (94.5 - 109.9)</td>
<td>103.9 (96.4 - 111.5)</td>
</tr>
<tr>
<td>Post</td>
<td>117.8 (110.2 - 125.5)</td>
<td>107.9 (98.7 - 117.1)</td>
</tr>
<tr>
<td>Diff</td>
<td>15.6 (10.1 to 21.1) *</td>
<td>3.9 (−0.1 - 7.9)</td>
</tr>
<tr>
<td>PPT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>310.8 (258.8 - 362.9)</td>
<td>302.5 (252.3 - 352.6)</td>
</tr>
<tr>
<td>Post</td>
<td>373.4 (313.6 - 433.1)</td>
<td>328.3 (275.6 - 381.0)</td>
</tr>
<tr>
<td>Diff</td>
<td>62.6 (33.6 - 91.5) *</td>
<td>25.9 (0.2 - 51.6) *</td>
</tr>
</tbody>
</table>

*Denotes a statistical significant difference p < 0.05.
3.6.2. PPT

There was a significant Time by Condition interaction for PPT (F (2,46) =3.4, p = .04), which demonstrated a mean improvement of 63 kPa following the application of the MWM (p = .000) pre- to post-treatment application compared with 26 kPa (p = .05) for the sham application and 20 kPa (p = .07) for the Control application. The mean differences between the MWM and Sham (45 kPa; p = .04) and between MWM and Control (46 kPa; p = .02) were statistically significant. There were no significant differences pre-application.

3.6.3. Methodological considerations

There was no loss to follow-up and no adverse effects reported. There was no carry-over effect when the pre-application data for all experiment sessions (i.e. before each intervention was applied) were evaluated.

3.7. DISCUSSION

This study demonstrated that the application of the Mulligan's MWM technique to participants with a painful restriction of shoulder movement produced an immediate and significant improvement in ROM and PPT pre- to post-intervention when compared to sham or control conditions. There are no other published studies of the effects of this technique on participants with shoulder pain. However, these findings are consistent with studies conducted in other joints of the body that have shown similar effects with the MWM techniques (Abbott et al., 2001; Collins et al., 2004; O'Brien & Vicenzino, 1998; Paungmali, Vicenzino, et al., 2003).

The clinical relevance of the magnitude of improvement in ROM gained following the MWM compared to the Sham (10°) after only one treatment session is arguably comparable to 42° improvement in abduction following four sessions of intensive massage (van den Dolder & Roberts, 2003), and 22° improvement after 4 to 10 sessions of individualised shoulder treatment (mainly exercises) over a month.(Ginn, K et al., 1997).

Wright (1995) has postulated that the mechanisms responsible for MT treatment effects (e.g. as in the increases in ROM and PPT in our study) may feasibly involve changes in the joint, muscle, pain and motor control systems (Wright, 1995). In our study, the standardised mean difference (SMD) for ROM (1.2) was greater than the SMD for PPT (0.9). The change in ROM was not related to the change in PPT (Pearson's correlation coefficient R = 0.29; p = .17) possibly indicating that the underlying mechanisms of the MWM may be related to local joint or muscle structures rather than the pain system.
The technical difference between the MWM and sham application was that the MWM involved the application of a posterolateral joint glide while the patient performed an active movement compared with the sham that involved no glide. This data, when considered along with studies showing that forward translation of the humeral head painfully limits shoulder movement (Ludewig & Cook, 2000), leads us to speculate that Mulligan's proposed mechanism of action for MWM's as a reduction of a positional fault may have some credence.

The application of the shoulder MWM also resulted in small but positive changes in PPT pre- to post- intervention. The mean differences between the MWM and the sham and the MWM and the control condition post-intervention were 45 kPa (95% CI: 2 - 88) and 45 kPa (95% CI: 9 - 84), respectively. Other studies of the upper limb have demonstrated similar effects in PPT following the application of a Mulligan's MWM (Paungmali, Vicenzino, et al., 2003; Vicenzino et al., 2001). These studies, along with others (Paungmali, O'Leary, et al., 2003; Souvlis et al., 2005; Sterling, M et al., 2001), have proposed that manipulative therapy may provide sufficient sensory input to activate the endogenous pain inhibitory systems. Further studies need to be conducted in the shoulder to determine if endogenous pain inhibitory systems are involved in manipulation-induced changes of PPT in the shoulder.

The comparison between the MWM and Sham conditions should also take into account that the latter limited abduction to half of the available range: that is, some of the difference between MWM and Sham may be attributable to the MWM utilising a greater range of abduction. Certainly, ethically it was undesirable to ask participants to experience repeated pain and pragmatically it is difficult to ensure compliance with return visits to the experiment if the subject was experiencing repeated painful movements at these visits.

A limitation of this study was that only the initial effects of the MWM were measured and the time-course of these effects is as yet unknown. Therefore, inferences drawn from this study should be limited to those seen in a single treatment session. Another limitation is that only measures of impairment (ROM, PPT) were made, but no measures of function or disability. Several case studies/series have shown that continued treatment with a MWM coincided with a resolution of the condition on function and disability measures (Hseih et al., 2002; Kochar & Dogra, 2002; Vicenzino, B. & Wright, 2001).
Further studies to evaluate such issues as the time-course of the effect of this particular MWM, and the outcome on disability and function after a course of treatment are warranted.

3.8. CONCLUSION

The results from this study indicate that the shoulder MWM may be a useful MT technique to apply to participants with a painful limitation of shoulder elevation to predominantly gain an initial improvement in ROM and PPT.
Chapter 4

One week time course of the effects of Mulligan’s MWM and taping in painful shoulders
This chapter includes a co-authored paper:


My contribution to the paper involved: subject recruitment, data collection, preliminary data analysis, write up and preparation for submission.

(Signed) _________________________________ (Date)______________

Student: Pamela Teys

(Countersigned) ___________________________ (Date)______________

Supervisor: Dr Leanne Bisset
ABSTRACT

Background: Previous research has shown that Mulligan’s MWM technique for the shoulder produces an immediate improvement in movement and pain.

Objective: The aims of this study were to investigate the time course of the effects of a single MWM technique and to ascertain the effects of adding tape following MWM in people with shoulder pain.

Design: Randomised controlled cross-over design

Methods: Twenty-five participants (15 males, 10 females) were randomly assigned to MWM or MWM-with-tape interventions. ROM, PPT and current pain severity (PVAS) were measured pre- and post-intervention, at 30 minutes, 24 hours and one-week follow-up. Following a one-week washout period, participants were crossed over to receive a single session of the opposite intervention with follow-up measures repeated.

Results: The MWM-with-tape intervention provided a significant improvement in ROM that was sustained over the follow-up period (p < .001; 18.1°, 95% confidence intervals (CI) 1.4 - 34.8). This intervention also significantly improved PVAS up to 30-minutes follow-up (38.4 mm, 95% CI 20.6 - 56.1 mm). The MWM intervention demonstrated an improvement in ROM immediately post-intervention (16.2°, 95% CI 7.0 to 25.4, p < .001), which was not sustained, and an improvement in PVAS that was maintained up to 30-minutes follow-up (42.6 mm, 95% CI 23.9 - 61.3 mm). There was no significant improvement in PPT for either intervention at any time point.

Conclusion: It appears that both MWM and MWM-with-tape provide an immediate improvement in pain and ROM. MWM-with-tape also provides a sustained improvement in ROM.
4.1. BACKGROUND

Shoulder pain with concomitant limitation of movement is a common problem, with a prevalence of approximately 20 - 33% in the general population (McBeth & Jones, 2007; van der Windt et al., 1995; Vermeulen et al., 2006) and as high as 46% in some sports (Smith et al., 2009). Physiotherapy treatment is often the first choice of management of shoulder symptoms (van der Windt et al., 1995), and MT techniques are commonly used to treat shoulder pain and functional limitations such as restricted range of movement (ROM).

Mobilisation-with-movement (MWM) is a MT technique that is gaining popularity for the management of musculoskeletal pain. It involves the application of a sustained glide to a painful or stiff joint by the therapist while the patient performs a concurrent active movement of the joint (Collins et al., 2004; Mulligan, 2003; Vicenzino et al., 2011). One preliminary study has demonstrated effectiveness in the use of MWM techniques on shoulder pain with limited ROM by improving ROM and pressure pain threshold (PPT), when compared to sham and no treatment (Teys et al., 2008). Specifically, this study used a posterolateral glide of the humeral head while the patient actively raised their arm in the plane of the scapula to the point of pain onset.

Mulligan proposes that MWM is clinically useful if a single application has a lasting effect (Collins et al., 2004), although there is very little evidence to demonstrate long-term effects with MWM. Furthermore, Mulligan also advocates the use of taping as an adjunct to the MWM technique, suggesting it may prolong the benefits of MWM (Collins et al., 2004). There is some low level evidence to support the use of taping in conjunction with MWM in improving pain and function in musculoskeletal conditions such as acute ankle inversion injury (O'Brien & Vicenzino, 1998), however the sustained effects of the MWM and the additional effects of taping in people with non-specific shoulder pain have not been investigated. The aim of this study was to assess the time course of the effects of one treatment session of MWM on participants with non-specific shoulder pain who responded positively to the application of a shoulder MWM, and to investigate the effects of adding tape to the MWM technique.

4.2. METHODS

A repeated measures, crossover, single-blinded, randomised trial was conducted to evaluate the time-course effects of a shoulder MWM and taping on ROM, pain severity
and PPT. This design was used to reduce the effects of individual variation and strengthen internal validity.

4.2.1 Participants

Twenty-five participants (Table 4.1) were recruited from the general community in southeast Queensland, Australia. Participants were included in the study if they were aged over 18 years, had reported pain in the anterosuperior aspect of one shoulder, duration of the shoulder condition for longer than 4 weeks, reduced shoulder elevation due to pain, and who responded positively to the application of the shoulder MWM at the initial screening. A positive response to the MWM was defined as a greater than 10 degrees’ improvement in pain-free ROM shoulder elevation in the plane of the scapula (Chen et al., 2009; Teys et al., 2008).

Volunteers were excluded from the study if they had a history of cancer, previous fractures of the shoulder complex, recent shoulder surgery or corticosteroid injection, any neurological or auto-immune disorder or any recent shoulder dislocation. In addition, volunteers were excluded if the shoulder pain was considered to be cervical in origin, based on a screening examination. This included active range of cervical motion testing and passive accessory cervical joint assessment. Volunteers were excluded if they had restriction of cervical movement and if their painful restriction of shoulder movement was found to be affected cervical joint accessory glides in the initial screening assessment. They were excluded if they had a known allergy to adhesive tape. An experienced physiotherapist with post-graduate physiotherapy qualifications and training in Mulligan’s techniques performed all screenings and interventions. Ethical clearance was obtained from the Institution’s Human Research Ethics Committee and all participants signed informed consent prior to enrolment in the study.

4.2.2 Outcome Measures

The outcome measures were range of shoulder ROM, PPT and pain severity, that were taken by an investigator skilled in their application and who remained blind to treatment allocation in both groups pre- and immediately post-intervention. Outcome measures were taken at baseline, immediately post-intervention, and at 30-minutes, 24-hours and 7-days post-intervention.
4.2.2.1. ROM

A universal goniometer was used to measure the participant’s pain-free shoulder abduction ROM in the plane of the scapula. The universal goniometer has been shown to have good intra-rater reliability if consistent landmarks are used (Hayes et al., 2001; Mullaney et al., 2010). Measurement was standardised by aligning the centre of the goniometer with the centre of axis of the shoulder joint posteriorly, one arm of the goniometer aligned with the lateral border of the scapula and the other arm aligned with the humerus (Teys et al., 2008). These points were marked with a permanent marker. To ensure arm elevation was in the plane of the scapula, one arm of the goniometer was placed along the superior border of the scapula with the other arm of the goniometer moved forward 30° from the coronal plane. A vertical line was marked on the wall to align with this. The participant was then asked to elevate their arm following the vertical line on the wall, with the thumb pointed upward for standardisation. Three measures were recorded and the average calculated for further data analyses.

4.2.2.2. Pain severity

Participants were asked to rate the severity of their current pain using a 0-100 mm visual analogue scale (PVAS; 0 = no pain at all, 100 = worst pain experienced). This has been validated as a reliable measure of pain severity (Gallagher et al., 2001).

4.2.2.3. PPT

PPT was measured over the point that was most painful to manual palpation of the anterosuperior aspect of the affected shoulder. A digital pressure algometer (Somedic AB, Farsta, Sweden) was used to measure the pressure applied to the site via a rubber tipped probe (1 cm²) held perpendicular to the skin. The pressure was applied at a rate of 40 kPa/s and the participant was asked to press a button immediately at the first onset of pain. Three measures were recorded and the average calculated for further data analyses. Pressure algometry has shown good inter-rater and intra-rater reliability and correlation with other measures of pain across all age groups (Walton et al., 2011).

4.3. INTERVENTION
All participants were randomised to receive a single intervention session consisting of three sets of 10 repetitions of MWM or MWM-with-tape. All participants then underwent one week of follow-up outcome assessment, followed by a one-week washout period. After the washout period, all participants received the opposite intervention (i.e., a single session of MWM or MWM-with-tape) and follow-up assessments for one week following the second intervention.

A physiotherapist blinded to the measures applied the shoulder MWM. The MWM procedure was explained to the participant prior to its application, including the explanation that it must be pain-free and that the MWM would cease immediately if any pain was experienced during the application (Hing et al., 2008; Mulligan, 2003; Teys et al., 2008). The participant was seated with an erect posture and feet flat on the floor. The therapist stood on the opposite side to the affected shoulder and applied the technique as described by Mulligan (Collins et al., 2004). With one hand over the spine of the scapula posteriorly and the thenar eminence of the other hand placed over the anterior aspect of the head of the humerus, the therapist applied a posterolateral glide to the humeral head of the affected shoulder, which was sustained while the participant raised their arm along the plane of the scapula without pain or discomfort as far as they could go or to the point of pain onset. Participants randomised to the MWM-with-Tape intervention then received tape applied to the affected shoulder. The skin was first wiped with alcohol and a single piece of porous hypoallergenic adhesive tape (Fixomull; Smith and Nephew, Brisbane, Australia) approximately 400 to 600 mm long and 50 mm wide, was applied to the shoulder. The participant was seated in an upright position and the tape was laid on the skin starting at the anterior shoulder and running over the acromion and diagonally down over the scapula to a point approximately level with T7 spinal segment. The treating therapist aimed to manually position the humeral head relative to the acromion as for the MWM manual technique while rigid sports tape (Leukosports, Beiersdorf AG, Germany) was applied overlying the Fixomull (Figure 4.1). All participants were given an education pamphlet regarding management of possible adverse reactions to tape along with instructions on how to remove the tape after 48 hours’ post-application or earlier if they experienced any discomfort or adverse reaction.
Figure 4.1. Lateral and posterior views of the taping technique used in the MWM-with-Tape intervention.
Figure 4.2. Flow chart time course of treatment and measures

Phone Screen = 250

Physical Screened = 107

Excluded = 143
Reasons: not in age range = 55
Duration of condition = 76
History of surgery = 12

Excluded = 82
Reasons: not severe enough = 25
Not appropriate for treatment = 13
Neck related symptoms = 15
Allergic to tape = 1
Did not respond to MWM = 28

Enrolled in study = 25

Baseline measures

MWM
N = 13

MWM-with-Tape
N = 12

Immediate post-application measures

30 min post-application measures

Lost to follow-up on doctor’s advice N = 1

24 hours post-application measures

Tape removed 48 hours post-application for the MWM-with-Tape group

7 days post-application measures

Lost to follow-up, too far to travel N = 1

1 week washout

All participants crossed over to receive other intervention and repeat all follow-up assessments as above
4.4. DATA ANALYSIS

The two independent variables in this study were Intervention (MWM, MWM-with-tape) and Time (baseline, immediately post-intervention, 30-minutes, 24-hours, and 7-days post-intervention). Data were entered into an electronic spreadsheet and intention-to-treat analyses were carried out using the Statistical Package for Social Sciences (SPSS V19.0, IBM Inc. Chicago, USA). Repeated measures analyses of variance (ANOVA) with within-subjects’ factors of Time, Order (of interventions), and a between-subjects factor of Intervention, with Bonferroni correction, were used. Post hoc testing was conducted on significant interaction or main effects (p < .05). A sample size of 24 was required based on 80% power to detect a 10° mean difference (standard deviation 19.3, p = .05) in ROM between interventions (Chen et al., 2009; Teys et al., 2008).

4.5. RESULTS

Twenty-five participants were recruited between February 2006 and February 2009 (Figure 4.2). There were two participants lost to follow-up, one from each intervention (Figure 4.2). The first participant dropped out after the first week due to the distance required for travel for assessments, and the other withdrew after day one for personal reasons. All participants received the intervention as allocated and there were no adverse events reported from either intervention. There was no significant difference for any outcome measure after the one-week washout period, suggesting that the washout period was effective. In addition, there was no order effect for any of the outcome measures, suggesting that the effects of the intervention were not influenced by whether the participant received, for example, tape during the first intervention session or the second.

There was a significant intervention (p = .001) and time effect (p < .001) for ROM, as well as a significant time x intervention interaction (p = .03). Post hoc testing revealed the MWM-with-Tape intervention was superior to the MWM intervention in improving ROM immediately post-intervention, and at 24-hours and one-week follow-up (Table 4.2). In addition, the MWM-with-Tape intervention showed significant improvement at all follow-up time points compared to baseline (Table 4.2). The only significant improvement in ROM from baseline for the MWM intervention, was immediately post-intervention (p < .001), but not beyond (Figure 4.3).
There were no significant differences over time within interventions (p = .7) or between interventions (p = .2) for PPT.

Pain severity (PVAS) was significantly different over time (p < .001) but not between groups (p = .7). PVAS significantly improved in both the MWM and MWM-with-Tape interventions from baseline to immediately post-intervention (mean improvement 38.6 mm, 95% CI 19.0 - 58.2, p < .001; and 35.6 mm, 95% CI 18.8 - 52.4, p < .001 respectively) and to 30 mins post-intervention (mean improvement 42.6 mm, 95% CI 23.9 - 61.3, p < .001; and 38.4 mm, 95% CI 20.6 - 56.1, p < .001 respectively), but not beyond (Table 4.2).

**Table 4.1.** Baseline participant characteristics (N = 25). Values are means (standard deviation) unless otherwise stated.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of men (%)</td>
<td>15 (60)</td>
</tr>
<tr>
<td>Age years</td>
<td>45.4 (14.8)</td>
</tr>
<tr>
<td>Number (%) right side dominant</td>
<td>24 (96)</td>
</tr>
<tr>
<td>Number (%) right side affected</td>
<td>16 (64)</td>
</tr>
<tr>
<td>Employment status (%)</td>
<td></td>
</tr>
<tr>
<td>Not working</td>
<td>2 (8)</td>
</tr>
<tr>
<td>Non-manual</td>
<td>14 (56)</td>
</tr>
<tr>
<td>Manual</td>
<td>9 (36)</td>
</tr>
<tr>
<td>Duration of condition months</td>
<td>7.7 (7.2)</td>
</tr>
<tr>
<td>Current pain†</td>
<td>49 (25)</td>
</tr>
<tr>
<td>Range of shoulder elevation degrees</td>
<td>97 (19)</td>
</tr>
<tr>
<td>Pressure pain threshold kPa</td>
<td>334 (148)</td>
</tr>
</tbody>
</table>

† 100 mm visual analogue scale; 0 mm=no pain, 100 mm=worst pain
Table 4.2. Means (standard deviations) of the MWM-with-tape and MWM groups at baseline and follow-up outcome measures, and between-intervention mean differences (95% confidence intervals), with Bonferroni correction.

<table>
<thead>
<tr>
<th></th>
<th>MWM-with-Tape</th>
<th>MWM</th>
<th>versus MWM†</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ROM (degrees)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>98.4 (23.8)</td>
<td>97.6 (30.9)</td>
<td>0.7 (-12.3 - 13.8)</td>
</tr>
<tr>
<td>Post-intervention</td>
<td>123.5 (23.4)*</td>
<td>112.7 (31.9)*</td>
<td>10.8 (1.1 - 20.4)*</td>
</tr>
<tr>
<td>30-minutes</td>
<td>118.8 (25.9)*</td>
<td>108.7 (35.1)*</td>
<td>10.1 (-0.3 - 20.4)</td>
</tr>
<tr>
<td>24-hours</td>
<td>118.8 (26.2)*</td>
<td>105.7 (23.2)</td>
<td>13.0 (2.6 - 23.5)*</td>
</tr>
<tr>
<td>7-days</td>
<td>117.2 (29.3)*</td>
<td>97.7 (38.1)</td>
<td>19.5 (8.5 - 30.4)*</td>
</tr>
<tr>
<td><strong>PPT (kPa)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>335 (151)</td>
<td>340 (142)</td>
<td>-5 (-49 - 37)</td>
</tr>
<tr>
<td>Post-intervention</td>
<td>345 (170)</td>
<td>344 (139)</td>
<td>1 (-46 - 47)</td>
</tr>
<tr>
<td>30-minutes</td>
<td>358 (183)</td>
<td>341 (144)</td>
<td>18 (-40 - 75)</td>
</tr>
<tr>
<td>24-hours</td>
<td>313 (158)</td>
<td>267 (109)</td>
<td>46 (-18 - 109)</td>
</tr>
<tr>
<td>7-days</td>
<td>321 (181)</td>
<td>325 (140)</td>
<td>-4 (-56 - 48)</td>
</tr>
<tr>
<td><strong>PVAS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>42.9 (25.7)</td>
<td>45.5 (26.8)</td>
<td>2.6 (-7.7 - 12.9)</td>
</tr>
<tr>
<td>Post-intervention</td>
<td>7.6 (11.0)*</td>
<td>8.6 (10.9)*</td>
<td>1.0 (-4.9 - 6.9)</td>
</tr>
<tr>
<td>30-minutes</td>
<td>4.7 (8.4)*</td>
<td>4.5 (6.8)*</td>
<td>-0.2 (-4.7 - 4.3)</td>
</tr>
<tr>
<td>24-hours</td>
<td>35.1 (22.1)</td>
<td>33.4 (27.9)</td>
<td>-1.7 (-12.1 - 8.7)</td>
</tr>
<tr>
<td>7-days</td>
<td>41.5 (32.3)</td>
<td>35.7 (26.8)</td>
<td>-5.7 (-20.1 - 8.6)</td>
</tr>
</tbody>
</table>

ROM: range of motion; PPT: pressure pain threshold; PVAS: current pain.

† Positive score favours the MWM-with-Tape intervention.

* p < .05
4.6. DISCUSSION

This is the first study to follow the short-term time course of response to a single intervention of MWM with and without tape in people who demonstrated an initial positive response to a MWM. We observed that an application of the shoulder MWM in conjunction with tape provided a statistically significant, and clinically meaningful (Mullaney et al., 2010) improvement of approximately 20° in ROM that was maintained for one week in people with shoulder pain. In contrast, the application of the MWM alone produced improvement in ROM only up to 30 min post-intervention.

These results provide evidence to support the clinical notion that tape augments the beneficial effects of MWM in musculoskeletal shoulder pain (Mulligan, 2004). The addition of tape to an MWM appears to preferentially improve ROM rather than pain, as improvement in ROM was significantly greater in the MWM- with- tape group at one-week follow-up, with no differences between groups for pain outcomes (PVAS or PPT) at any time point.

Our findings of improvement in ROM with tape are consistent with other studies that have investigated the effects of tape on other musculoskeletal conditions. A single application of tape similar to the one used in this study was found to significantly increase external rotation shoulder ROM in elite junior tennis players (McConnell & McIntosh, 2009). Tape has also been shown to enhance ankle ROM (O’Brien & Vicenzino, 1998),
increase and maintain arch height after 10 min of walking (Franettovich et al., 2010b), and maintain arch height during a jump-drop landing task (Cordova et al., 2010). In contrast to ROM, improvements in current pain severity were not maintained beyond 30-min follow-up for either intervention. There is conflicting evidence around the effect of taping on pain. One previous study reported no significant difference in PPT between a tape and sham tape condition in people with tennis elbow (Vicenzino et al., 2003), whereas other studies have found a significant reduction in pain following the application of tape in conditions such as patellofemoral pain syndrome, shoulder pain and plantar fasciitis (Lan et al., 2010; Radford, Landorf, et al., 2006; Wang, 1999). Due to conflicting evidence regarding the contribution of tape to reducing pain, the mechanism underlying tape in shoulder conditions warrants further investigation.

The mechanisms underlying MWM or tape are unclear, but are likely to be multifactorial. Under both static and dynamic conditions, taping has been shown to change biomechanical parameters at other body parts, such as increased vertical navicular and medial longitudinal arch heights, reduced tibial internal rotation and calcaneal eversion, as well as alter foot plantar pressure patterns (Franettovich et al., 2010b; Franettovich et al., 2008b; Radford, Landorf, et al., 2006; Vicenzino et al., 2005; Vicenzino et al., 2007). MWM may also produce a biomechanical change, evidenced by a cadaveric study that showed a technique replicating the glenohumeral MWM produced a 7.7 mm posterior displacement of the humeral head during shoulder abduction (Bradley et al., 2009).

An alternative mechanism of effect for MWM may be neurophysiological, as MWM produces rapid hypoalgesia and sympathoexcitation, greater than effects seen with placebo or control conditions (Paungmali, O’Leary, et al., 2003; Vicenzino, B. et al., 1996). One explanatory mechanism underlying this manipulative therapy induced pain modulation is the activation of the descending pain inhibitory system within the central nervous system, initiated by stimulation of the lateral-dorsal periaqueductal gray (Paungmali, Vicenzino, et al., 2003; Sterling, M et al., 2001; Vicenzino et al., 1998; Wright, 1995). To our knowledge, no studies have investigated the mechanisms underpinning the clinical effects of tape or MWM in the shoulder.

This is the first study to investigate the one-week time course of response to a single treatment of MWM with and without tape. There is a dearth of comparable research on the time course of effects of other MT techniques. In people with low back pain, a single
session of the Mulligan MWM (bent-leg-raise technique in people with low back pain), has previously demonstrated improvement in straight leg raise ROM and pain severity immediately post-intervention, that was sustained for 24 hours (Hall et al., 2006). Similarly, a single lower cervical manipulation has previously demonstrated significant amelioration of lateral flexion ROM asymmetry in the cervical spine at 30 minutes and at 4 hours follow-up in people with a history of neck trauma, with improvements sustained up to 48 hours follow-up in people with no history of neck trauma (Nansel et al., 1990). While our study demonstrated a single session of MWM-with-Tape has a sustained effect (up to one week) on improvement in ROM, it would be interesting to investigate the additive effects of repeated treatment sessions over time on outcomes in shoulder pain.

Comment is warranted on the fact that our study investigated the effects of a single treatment session of MWM with and without tape. This is not representative of standard physiotherapy practice, which commonly involves more than one treatment session and a multimodal approach (Ginn, K et al., 1997). Given the positive effects of a single intervention of MWM-with-Tape as identified in our study, there is a need to investigate the short- and long-term effects. Improvements in current pain severity were not maintained beyond 30-minutes follow-up for either intervention. There is conflicting evidence around the effect of taping on pain. One previous study reported no significant difference in PPT between a tape and sham tape condition in people with tennis elbow (Vicenzino et al., 2003), whereas other studies have demonstrated a significant reduction in pain following the application of tape in conditions such as patellofemoral pain syndrome, shoulder pain and plantar fasciitis (Lan et al., 2010; Radford, Burns, et al., 2006; Wang, 1999). Due to conflicting evidence regarding the contribution of tape to reducing pain, the mechanism underlying tape in shoulder conditions warrants further investigation.

It must also be noted that the participant population used in this study were likely to have been heterogeneous in terms of diagnostic category, as the primary inclusion criteria was pain that limited shoulder range of movement, which may be associated with a variety of shoulder conditions. This is not necessarily a limitation of the study, because two systematic reviews, which summarised approximately 50 diagnostic tests for shoulder conditions, have shown that there are very few tests of diagnostic value to clinicians (Hegedus et al., 2008; Snyder, 2009). Thus, heterogeneity in our sample population might improve the translation of findings to a broad patient population in normal physiotherapy practice. However, another primary inclusion criterion for the sample in this study was that
participants should have an immediate positive response to MWM during the screening procedure. This limits the translation of the findings to the general patient population.

Another limitation of this study is the absence of blinding of both the outcome assessor and study participants to the interventions. While best efforts were made to ensure the outcome assessor remained impartial during the assessments, the risk of bias should be considered when interpreting the findings of this study.

For people with shoulder pain who have demonstrated a positive response to an initial MWM, MWM-with-Tape provides a sustained improvement in ROM, but not pain, to one-week follow-up, which is superior to MWM alone.

4.7. CONCLUSION

In people with shoulder pain who demonstrated a positive response to an initial MWM, a single intervention of MWM-with-tape provided an improvement in ROM for up to one week, compared to MWM alone. This current study adds to the growing body of evidence demonstrating positive sustained effects of MWM in combination with tape, and may help direct treatment planning for patients with musculoskeletal shoulder complaints.
Chapter 5
The immediate effects of scapulothoracic MWM on pain-limited shoulder movement: within subjects randomised trial
STATEMENT OF CONTRIBUTION TO A CO-AUTHORED PAPER

This chapter includes a co-authored paper prepared for publication. The details of the article, including all authors, are:

Teys, P, Bisset, L, Coombes, B, Collins, NC, Vicenzino, B. The immediate effects of scapulothoracic MWM on pain-limited shoulder movement: within subjects randomised trial

My contribution to the paper included: subject recruitment, data collection, data analysis, write up and preparation for submission.

(Signed) _________________________________ (Date)______________

Student: Pamela Teys

(Countersigned) ___________________________ (Date)______________

Supervisor: Dr Leanne Bisset
5.1. INTRODUCTION

Shoulder pain of musculoskeletal origin is commonly treated conservatively using a variety of interventions, including MT and exercise (Bergman et al., 2004; Bergman et al., 2002; Ginn, K. & Cohen, 2005; Kachingwe et al., 2008). One group of MT techniques for which there is a growing body of evidence for the treatment of patients with musculoskeletal pain conditions and movement disorders, is Mulligan’s MWM (Abbott et al., 2001; Collins et al., 2004; Vicenzino et al., 2001). MWM is the application of a sustained passive accessory glide to a joint while the patient performs a previously pain-limited active movement or functional task. Clinically, treatment with MWM is warranted when an immediate improvement in pain-free movement is noted.

Some studies have shown that a MWM technique applied to the glenohumeral joint provides improvement in pain-free active shoulder elevation and an increase in PPT in people with pain-limited shoulder movement (Delgado-Gil et al., 2015; Djordjevic et al., 2012; Teys et al., 2008). Clinically, not all patients respond to glenohumeral MWM and Mulligan suggests that in such a case, the clinician should attempt treatment with an alternative MWM technique (Hing et al., 2008; Mulligan, 2004; Vicenzino, B. et al., 2007). For the shoulder complex an alternative technique might be MWM applied to the scapula given the role of scapulothoracic motion to achieve full range of pain-free shoulder movement (Kibler et al., 2012; Lawrence et al., 2014; Ludewig & Cook, 2000; Ludewig & Reynolds, 2009; McClure et al., 2006; Michener et al., 2003).

Several authors have confirmed that abnormal scapular kinematics (also known as scapular dyskinesis) is associated with glenohumeral pathology (Karduna et al., 2005; Ludewig & Cook, 2000; Ludewig & Reynolds, 2009; McClure et al., 2006). During shoulder elevation, the scapula should upwardly and externally rotate as well as posteriorly tilt (Kibler et al., 2012; Ludewig & Reynolds, 2009; McClure et al., 2006; McClure et al., 2001). Non-optimal scapular movement is believed to lead to a reduction of the subacromial space, which may in turn lead to compression of its contents and result in pain (Ludewig & Reynolds, 2009; Solem-Bertoft et al., 1993).

In light of the contribution of scapular kinematics to shoulder pain, and in accordance with Mulligan’s recommendation to trial an alternative MWM technique in people who
fail to respond to the initial technique, the aim of this study was to assess if a scapulothoracic MWM would have immediate effects on pain-free ROM and PPT in people with pain-limited shoulder movement, who failed to respond to a glenohumeral MWM.

5.2. METHODS

A randomised observer-blinded controlled, cross-over trial design was used to study the immediate effects of a scapulothoracic MWM on ROM and PPT in this specific group of participants.

5.2.1. Participants

Participants were recruited from the general community by word of mouth, local newspapers, and advertising in a university Bulletin and via email. Inclusion criteria were: people between 18 and 65 years of age who had suffered shoulder pain during movement for at least 6 weeks’ duration (Teys et al., 2008), had a history consistent with shoulder pathology, and positive physical examination findings of pain-restricted movement in the plane of the scapula, a positive Hawkins Kennedy test, pain on palpation over the anterolateral aspect of the shoulder, as well as either a positive Neer’s impingement test or a painful arc of movement (Cleland & Koppenhaver, 2007; Hegedus et al., 2008; Hegedus et al., 2012). In addition, people were included only if they failed to respond by a greater than 10° improvement in shoulder elevation to a glenohumeral MWM (Hing et al., 2008; Mulligan, 2004; Teys et al., 2008; Vicenzino et al., 2011).

Exclusion criteria included a history of cancer, previous fractures of the shoulder complex, and shoulder surgery or corticosteroid injection in the previous 12 months, any neurological or autoimmune disorder, or any recent shoulder dislocation. Volunteers were also excluded if, based on a screening examination, the shoulder pain was considered to be of cervical origin. This was determined by an experienced musculoskeletal physiotherapist through assessment of reported area of pain, evidence of sensory and motor changes in a dermatomal or myotomal distribution (Radhakrishnan et al., 1994), restriction of cervical active ROM, and pain reproduction with passive accessory glides on the cervical facet joints (Tampin et al., 2012). Potential volunteers were excluded if they presented with symptoms of acute pain and stiffness indicative of early stage adhesive capsulitis (Walmsley et al., 2009). This study was approved by the University of Queensland and Griffith University’s Human Research Ethics Committees and written informed consent
was gained from all participants prior to their enrolment into the study. People who met the eligibility criteria and responded positively to the glenohumeral MWM were enrolled in a previous study (Teys et al., 2008). All treatment and assessments were conducted in a laboratory setting within the university. The sample size was calculated from the difference in change scores between the MWM and Sham interventions reported in a previous study (Teys et al., 2008). A sample of 18 participants was deemed sufficient to identify a between-group difference of 11.7° (SD 16.3°) at 80% power (alpha = 0.05). However, it was anticipated that there may be fewer responders in this study compared to the previous study (Teys et al. 2008), given that the participants in the current study had already failed to respond to a glenohumeral MWM technique. It was therefore decided to increase the sample size to 28, to minimise the risk of a Type II error.

5.2.2. Outcome Measures

Participants’ demographic and clinical characteristics were recorded on enrolment into the study. Current pain and worst pain over the previous 24 hours were recorded prior to each intervention using a 0-100mm visual analogue scale (VAS), with 0 being no pain at all, and 100 being the worst pain imaginable (Appendix 18) (Bijur et al., 2001). The outcome measures were pain-free shoulder elevation ROM in the plane of the scapula and PPT, measured before and after each intervention. A research investigator skilled in their application took all outcome measures. This investigator remained blind to the intervention allocation for the duration of the study.

The participant’s active arm elevation to the point of pain onset was measured with a universal goniometer (Watkins et al., 1991). The universal goniometer has been shown to have good inter- and intra-rater reliability between days and compared with a digital level inclinometer in patients with shoulder pathology if consistent surface anatomical landmarks are used (ICC = 0.96, 95% LOA 6 - 11°) (Hayes et al., 2001; Mullaney et al., 2010). The axis of movement of the goniometer was aligned with the axis of movement of the shoulder posteriorly. One arm of the goniometer was aligned vertically, parallel with the thoracic spine, and the other arm along the humerus to align with the lateral epicondyle (Hayes et al., 2001). The reference points were marked with a permanent marker. Elevation in the plane of the scapula was defined as 30⁰ forward from the frontal plane. This was achieved by aligning the axis of the goniometer along the superior aspect of the shoulder, moving one arm of the goniometer forward to align 30⁰ forward from the coronal
plane while the other goniometer arm remained in the coronal plane. A line corresponding to the alignment of the goniometer was marked on the wall with tape to aid test–retest repeatability. The participant was then asked to actively elevate the affected arm along that line with the thumb pointed upward for standardisation, and asked to stop immediately upon onset of pain. A measure of active ROM was taken. This process was repeated three times and the mean was used in further analyses.

PPT is a validated, quantifiable measure of mechanical hyperalgesia (Chesterton et al., 2007; Nussbaum & Downes, 1998; Walton et al., 2011), and was used in the current study to assess the effect of the MWM on mechanical hyperalgesia over the anterior aspect of the shoulder. Local nociceptive hypersensitivity has been demonstrated in individuals with shoulder pain and shoulder impingement syndrome (Coronado et al., 2011) and PPT over the local area has previously been shown to be responsive to MWM (Paungmali, O’Leary, et al., 2003; Teys et al., 2008; Vicenzino et al., 2003). A digital pressure algometer (Somedic AB, Farsta, Sweden) with a rubber tipped probe (area 1 cm²) was applied over the most tender point of the anterosuperior aspect of the affected shoulder and was held at 90° to the skin surface. This point was located by palpation and a permanent marker was used to mark the location so that the same point could be located pre- and post-intervention. Pressure was applied at a rate of 40 kPa/sec and the participant was asked to press a button immediately when the feeling of pressure changed to a feeling of pressure with pain (threshold of pain onset). This process was repeated 3 times with a 30-second rest interval between measures, and the average was used in further analyses to represent the dependent variable of mechanical hyperalgesia (Chesterton et al., 2007; Jones et al., 2007).

5.3. PROCEDURE

Scapulothoracic MWM, sham and control interventions were applied in a random order over 3 separate sessions, with a minimum of 48 hours between sessions to minimise carry-over effects between interventions. A person not involved in the study generated the randomisation schedule prior to study commencement. The treating therapist, who was also responsible for screening and enrolling participants into the study, held that sequence throughout the study. Participants were informed that the study was investigating the effects of manual handling, positioning, and movement and that they would experience manual handling and positioning of the shoulder blade in 2 different ways, along with movement of the shoulder. These instructions were provided to make the participants consider both the sham and MWM interventions as techniques of interest to this study.

5-65
The physiotherapist who applied the interventions and who was blind to the pre- and post-outcome measures (i.e. played no part in taking the outcome measures), had received formal training in the application of Mulligan’s MWM techniques, held a post-graduate Master’s degree, and had more than 20 years of clinical experience. Importantly, the randomisation schedule was concealed from the outcome assessor throughout the testing period, and participants were requested not to divulge the intervention order to the outcome assessor.

5.4. INTERVENTIONS

The MWM intervention consisted of the application of a glide to the scapula that corrected or facilitated scapular movement with the aim of providing full pain-free or improved arm elevation in the scapular plane (Figure 5.1) (Kibler & Sciascia, 2010; Kibler et al., 2012; Ludewig et al., 1996; McClure et al., 2009). The participant was seated in a neutral spine position with both feet flat on the floor. The physiotherapist stood on the side opposite to the affected shoulder and placed one hand posteriorly on the scapula and the other hand anteriorly along the length of the clavicle. The treating therapist manoeuvred the participant’s scapula into a starting position that was considered neutral (i.e. positioning the medial border of the scapula parallel to the thoracic spine and the scapula in approximately 30° of internal rotation and 10° of anterior tilt) (Kibler et al., 2012; Sahrmann, 2002; Struyf et al., 2011). Using clinical judgement, the therapist then applied a MWM to the scapula to facilitate “optimal” scapular movement while the participant actively elevated the affected arm along the plane of the scapula to the point of pain onset. The treating therapist adjusted the glide by slight alteration to either the upward or external rotation component or to the posterior tilt or a combination of those movements of the scapula, to achieve the best possible change in ROM. Once reached, that position was momentarily sustained before the participant returned to the starting position while the therapist maintained scapular positioning. The MWM was released at the end of each movement. Three sets of 10 repetitions were performed with 1-minute rest provided between sets. If there was no improvement in active pain-free ROM the scapulothoracic MWM was modified to apply either greater or less upward rotation, retraction or external rotation.
The sham intervention involved the therapist placing one hand posteriorly on the thoracic spine and the other hand anteriorly along the clavicle. The participant was again asked to perform three sets of 10 repetitions of shoulder elevation and to stop when pain was experienced, as per the MWM intervention. No pressure was applied to the thoracic spine during the manoeuvre as facilitation of thoracic extension or thoracic manipulation could conceivably contribute to an improvement in arm elevation ROM (Crawford & Jull, 1993; Mintken, 2015).

The control intervention consisted of the participant sitting and waiting for the same approximate length of time as it took to perform the MWM or sham intervention, but no shoulder movement was performed and no physical contact made by the treating therapist.
Figure 5.2. Flow chart of participants through the study.
5.5. DATA MANAGEMENT

Data were entered into an electronic spreadsheet and intention-to-treat analyses were performed using the Statistical Package for Social Sciences (SPSS v20.0, IBM Inc. Chicago, USA). Firstly, to ensure that outcome measures returned to baseline prior to each intervention and thereby satisfying this condition for a cross-over study design, a repeated measures 1-way analysis of variance (ANOVA) was used (p < .05) to assess consistency in pre-intervention measures. Secondly, change scores were calculated for each intervention, and a repeated measures 1-way ANOVA was then performed on each of the dependent variables (ROM, PPT) to test the hypothesis that MWM produced changes in excess of sham and control (p < .05). The standardised mean difference (SMD = mean difference/pooled standard deviation) was calculated to determine the magnitude of the difference between interventions, with < 0.5 considered a small effect, between 0.5 and 0.8 a medium effect, and > 0.8 a large effect (Cohen, 1988). Thirdly, the minimal detectable change (1.96*√(2*SEM)) was calculated from the mean of three trials of baseline ROM measures, as a metric for the minimum amount of change required to be 95% confident that the difference between the two measurements represents a true change. Participants were then categorised as responders or non-responders according to whether or not they achieved a change in ROM equal to or higher than the minimal detectable change. The proportion of participants rated as successful versus unsuccessful between interventions was then assessed using a repeated measures logistic regression (p < .05).

5.6. RESULTS

Twenty-eight participants (13 men, (mean 45.4 years; SD 14.5 years), 15 women, (mean 44.1 years; SD 11.6 years) were enrolled between November 2006 and November 2011 (Table 5.1). All participants received the interventions in the order allocated and there was only one adverse event reported by one participant, who experienced a temporary increase in shoulder pain after the sham intervention. This participant consequently withdrew after the first session (Figure 5.2). Of the remaining participants (n = 27), two had missing PPT data due to equipment malfunction on the day of testing. Consequently, data from 27 participants are included in the ROM analyses and data from 25 participants are included in the PPT analyses. No imputation of missing data was performed.
Table 5.1. Baseline participant characteristics; values are means (standard deviations) unless otherwise stated.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>N=28</th>
</tr>
</thead>
<tbody>
<tr>
<td>Women n (%)</td>
<td>15 (54)</td>
</tr>
<tr>
<td>Age years</td>
<td>44.7 (12.8)</td>
</tr>
<tr>
<td>Dominant side right n (%)</td>
<td>27 (96)</td>
</tr>
<tr>
<td>Dominant side affected n (%)</td>
<td>14 (50)</td>
</tr>
<tr>
<td>Symptom duration weeks</td>
<td>23.6 (19.5)</td>
</tr>
<tr>
<td>Employment status n (%)</td>
<td></td>
</tr>
<tr>
<td>*Not working</td>
<td>4 (14)</td>
</tr>
<tr>
<td>Non-manual</td>
<td>18 (64)</td>
</tr>
<tr>
<td>Manual</td>
<td>6 (22)</td>
</tr>
</tbody>
</table>

% = percentage

*Not working = unemployed or homemaker; Non-manual = office, clerical or other desk work; Manual = other. PVAS = pain on a visual analogue scale
Table 5.2. Means (standard deviation) for ROM and PPT for pre- and post-intervention and change over time, and between-intervention mean differences (95% confidence intervals).

<table>
<thead>
<tr>
<th></th>
<th>MWM</th>
<th>Sham</th>
<th>C</th>
<th>Mean Difference (95% CI)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>MWM-Sham</td>
</tr>
<tr>
<td><strong>ROM ° (n= 27)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-intervention</td>
<td>93.4 (23.1)</td>
<td>94.2 (24.2)</td>
<td>97.4 (23.9)</td>
<td>3.8 (0.4 - 7.1)†</td>
</tr>
<tr>
<td>Post-intervention</td>
<td>103.6 (26.5)</td>
<td>100.6 (25.9)</td>
<td>99.8 (24.7)</td>
<td></td>
</tr>
<tr>
<td>Change score</td>
<td>10.2 (16.4)</td>
<td>5.9 (16.0)</td>
<td>2.5 (4.7)</td>
<td>3.8 (0.4 - 7.1)†</td>
</tr>
<tr>
<td><strong>PPT kPa (n=25)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-intervention</td>
<td>257.1 (137.9)</td>
<td>247.4 (130.2)</td>
<td>247.1 (154.1)</td>
<td></td>
</tr>
<tr>
<td>Post-intervention</td>
<td>258.6 (140.7)</td>
<td>250.6 (129.3)</td>
<td>253.3 (152.5)</td>
<td></td>
</tr>
<tr>
<td>Change score</td>
<td>1.5 (59.9)</td>
<td>3.2 (57.8)</td>
<td>6.3 (61.4)</td>
<td>-1.8 (-35.9 - 32.3)</td>
</tr>
</tbody>
</table>

Abbreviations: C = Control; MWM = Mobilisation-with-movement; PPT = pressure pain threshold; ROM = range of movement
* Positive score favours the first treatment group
† p < .05
There was no significant difference in ROM (p = 0.3), PPT (p = 0.7) or pain severity (p < .001) between the three pre-intervention assessments (Table 5.2) suggesting that the 48-hour period between interventions was sufficient to return measures to their baseline value.

The scapulothoracic MWM produced a small, but significantly greater increase in ROM compared to both the sham (mean difference 3.8° (95% CI: 0.4 - 7.1), SMD = 0.4; p = .03) and control conditions (7.7° (1.1 - 14.4) SMD = 0.5; p = .03; (Table 2)), with no significant difference between sham and control conditions (SMD = 0.2; p = .22). Eleven participants (38.4%) achieved a minimum improvement greater than the minimal detectable change of 10° in shoulder ROM following the MWM, compared with six (19%) and four (11.5%) participants following the sham and control interventions, respectively. Overall, there was no significant difference in the number of responders between interventions. (p = 0.078) (Figure 5.3).

![Figure 5.3. Number of responders (≥ 10° improvement in ROM) to each intervention.](image)

Participants who did not respond to the scapulothoracic MWM had a longer duration of shoulder pain (26 months versus 21 months), and higher baseline reported pain (44 versus 33/100 mm) compared to those who did respond.

There was no significant difference in PPT between interventions (p = 0.95).

5.7. DISCUSSION
To our knowledge, this is the first study to investigate the effects of scapulothoracic MWM in individuals with pain-limited shoulder movement who had previously failed to respond to glenohumeral MWM. We found a statistically significant improvement in pain-free ROM following scapulothoracic MWM compared to both sham and control interventions, with small to moderate effect sizes. However, the scapulothoracic MWM did not significantly improve ROM beyond the minimal detectable change (10°) compared to the sham intervention. It is possible that the lack of statistical difference between groups may be due to a Type II error. That is, the lack of statistical significance may be due to an insufficient sample size. It should be remembered that all participants in this study had failed to respond to a trial treatment of glenohumeral MWM. Yet, 11 participants (38%) responded positively to the scapular MWM, compared to 6 participants (19%) who responded positively to the sham intervention.

A common component of both the MWM and sham was the active shoulder elevation to onset of pain. Given there were only four (11%) participants who exhibited greater than 10° improvement with the control intervention, it may be reasonable to suggest repeated elevation within pain limits was responsible for some part of the observed increases in ROM with scapulothoracic MWM and sham interventions. Repeated, active, pain-free movements of a joint have a positive effect (Vaegter et al., 2016). Participants were informed that they would receive handling and positioning of the shoulder blade in two different ways. Secondly, the contact of the therapist's hands on the thoracic spine may have had some positive effect given the well-documented association between thoracic spine movement and shoulder movement (Crawford & Jull, 1993; Strunce et al., 2009; Sueki & Chaconas, 2011). Touch over the thoracic spine may have had an influence on thoracic extension posture sufficient to influence shoulder movement (Crawford & Jull, 1993; Lewis et al., 2005).

It is important to note that, while the goal of the scapulothoracic MWM was to improve pain-free range of shoulder movement by adjustment of the scapula, the position and movement of the scapula was not assessed in this study (Lewis, 2009). There is evidence to support the association between scapular dyskinesis (i.e. abnormal movement of the scapula) and shoulder pain syndromes (Ludewig & Cook, 2000; Ludewig & Reynolds, 2009; Lukasiewicz et al., 1999; Warner et al., 1992). Assessment of scapular position and movement however lacks diagnostic accuracy (McClure et al., 2009; Shadmehr et al., 2010; Tate et al., 2008), and there is poor correlation between scapular
position and clinical presentation (Tate et al., 2009). Therefore, rather than assessing scapular dyskinesis, it was proposed that identification of a possible symptom altering technique may be more clinically relevant to direct treatment (Kibler et al., 2006; Lewis, 2009; Seitz et al., 2012; Tate et al., 2008).

There is some similarity between scapulothoracic MWM and other scapular modification procedures that have been trialled. These procedures have all involved some form of scapular correction while the participant performed shoulder movement (Kibler et al., 2006; Seitz et al., 2012; Tate et al., 2008). There have been somewhat conflicting results. Kibler et al (Kibler et al. 2006) and Tate et al (Tate et al., 2008) both reported improvement in rotator cuff muscle strength with a scapular correction manoeuvre, whereas Seitz et al (Seitz, 2012) found no improvements in strength of the rotator cuff muscles with a “scapular assistance test”. Shoulder Symptom Modification Procedures (SSMP) described by Lewis (Lewis, 2009) include a scapular corrective technique. He describes a series of manual interventions applied while the patient performs a shoulder activity or movement that most closely reproduces their symptoms. Lewis has proposed that if one intervention or a combination of intervention manoeuvres results in a substantial improvement in the patient’s symptoms, then similar interventions or a combination of interventions may be indicated for use in treatment (Lewis, 2009). SSMP’s have been suggested as an alternative assessment and treatment approach but have not yet been validated by laboratory studies. Participants in our first study who had failed to respond to a glenohumeral MWM were trialled with scapulothoracic MWM. Future research could be directed towards applying a combination of these techniques if one or the other does not produce improvement in patient symptoms.

Identifying the clinical characteristics of those who do not respond to either glenohumeral or scapulothoracic MWM may also help to develop more effective treatments that are individualised to the patient. It is possible that this cohort represents a subset of people who demonstrated a generalized non-hypoalgesic response to MWM techniques. Clear guidelines for identifying people with shoulder pain who are more likely to respond favourably to MWM are scarce. Some baseline clinical characteristics, such as high disability and longer duration of symptoms, are known to negatively influence outcomes in people who have undergone other physiotherapy treatment for shoulder pain (Chester et al., 2013). Observationally, participants in the current study who
did not respond to the scapulothoracic MWM had reported higher baseline pain severity and longer duration of shoulder pain compared to those who did respond.

There is a growing body of evidence to suggest that central sensitisation may play a role in reducing treatment effects in people with chronic musculoskeletal pain. A recent systematic review identified evidence of widespread mechanical hyperalgesia in chronic tendinopathy conditions, including shoulder pain (Backonja et al., 2013). Widespread mechanical hyperalgesia is considered analogous with central sensitisation (Backonja et al., 2013). Features of central sensitisation, such as deficits in cold and mechanical pain thresholds, are significantly predictive of pain and disability status at 12 months in other chronic musculoskeletal conditions such as lateral epicondylalgia (Coombes et al., 2012, 2015). It was not our intention to perform any sub-group analyses in this study as our sample size was not large enough to confirm these findings. In addition, we only assessed PPT at the affected shoulder, so evidence of reduced PPT at other body locations is missing from this study. Notwithstanding this, participants in our study exhibited lower PPT values (250.5 kPa) compared to a previous study by the same authors (Teys et al., 2013; Teys et al., 2008), potentially reflecting a cohort with more severe symptoms. The people in this study who were unresponsive to the glenohumeral MWM at the initial assessment, had a baseline PPT approximately 58 kPa lower than the people who responded positively to the baseline glenohumeral MWM (307 kPa) (Chapter 3) (Teys et al., 2008). The role of PPT as an assessment tool to direct treatment in people with shoulder pain should be further explored (Backonja et al., 2013).

One further consideration is that one research investigator was responsible for screening all participants and performing all interventions. While this dual role may have potentially introduced bias into the study, each participant received all three interventions and the outcome assessor was blind to the order of the interventions, thereby strengthening the internal validity of this study.

5.8. CONCLUSION

In people with shoulder pain who were not responsive to a glenohumeral MWM, a small number achieved a clinically important improvement in pain-free shoulder ROM
immediately following scapulothoracic MWM and a sham intervention (essentially repeated elevation to pain onset).
Chapter 6
Mulligan’s MWM plus tape and exercise versus exercise alone for patients with musculoskeletal shoulder pain: a RCT

ANZCTR registration: ACTRN12613000859785
6.1. INTRODUCTION

Musculoskeletal shoulder pain is a debilitating problem that accounts for up to 23% of people who visit a general medical practitioner each year (Hébert et al., 2003; Van der Windt et al., 1996). The point prevalence of shoulder pain in the general population has been estimated to range from 6-14% with a lifetime prevalence as high as 66% (Luime et al., 2004). It is the leading cause of sick days in the United States and the cost of treatment of shoulder dysfunction has been estimated at $7 billion annually (Brudvig et al., 2011; Camarinos & Marinko, 2009; Kuijpers, van Tukler, et al., 2006; Virta et al., 2012).

Conservative treatment that includes MT has positive effects on patients with musculoskeletal shoulder pain (Camarinos & Marinko, 2009; Desmeules et al., 2003; Ho et al., 2009). However, not all people with shoulder pain recover following conservative treatment (Camarinos & Marinko, 2009; Marinko et al., 2011; van der Windt et al., 1995). The presence of central sensitisation, as identified by high levels of baseline pain, widespread mechanical hyperalgesia and impairment in cold pain threshold, may be influential in affecting response to treatment of musculoskeletal disorders (Woolf, 2011). Preliminary evidence to support this suggestion is limited and only one RCT has identified mechanical and cold hyperalgesia and latent trigger points in people with chronic shoulder impingement (Hidalgo-Lozano et al., 2010).

There is evidence that Mulligan’s glenohumeral MWM is effective in providing immediate improvement in shoulder pain and dysfunction (Djordjevic et al., 2012; Kachingwe et al., 2008; Teys et al., 2013; Teys et al., 2008). A single application of glenohumeral MWM has demonstrated immediate positive effects in improving pain and range of movement in a shoulder pain population when compared with placebo and controls (Teys et al., 2008). It has also demonstrated a positive effect in terms of improved pain-free movement for at least one week when tape is added (Teys et al., 2013; Teys et al., 2008). Furthermore, there is evidence of a positive effect with the inclusion of MWM as part of a multimodal treatment plan in other areas of the body (Bisset et al., 2006; Paungmali, O’Leary, et al., 2003), but currently very little evidence for the added benefits of glenohumeral MWM in a treatment programme for chronic shoulder pain. Based on the current debate in the literature regarding the additive effects of MT to exercise for the shoulder there is a need to investigate if the addition of
glenohumeral MWM-with-tape to an exercise programme provides added benefit over exercise alone.

The aim of this study was to conduct a pilot RCT to establish the feasibility of running a fully powered RCT that will compare the effects of therapeutic exercise with a multimodal programme of exercise and glenohumeral MWM-with-tape. It is anticipated that the results of this pilot study would inform sample size calculations for the conduct of a larger RCT with long-term follow-up. A secondary aim was to assess the feasibility of using quantitative sensory measures to identify a sub-group of people for whom a glenohumeral MWM approach is or is not beneficial.

6.2. METHODS

6.2.1. Study Design

A repeated measures single blinded, randomised clinical trial with short-term follow-up was conducted to evaluate the comparative effects of a treatment regime of therapeutic exercise versus exercise plus glenohumeral MWM-with-tape in people with chronic pain limited shoulder movement.

6.2.2. Participants

Participants were recruited from the local community by university email and newspaper advertisements. Initial screening for inclusion into the study was conducted by the chief investigator (PT) via telephone or email. Volunteers were included if they were aged between 18 and 65 years, were experiencing shoulder pain in the anterior or anterolateral aspect of the affected shoulder of at least 6 weeks’ duration, that was affecting their ability to lift their arm overhead, and with a history consistent with shoulder pathology (Hegedus et al., 2008). Exclusion criteria included a history of cancer, recent fractures or dislocations around the shoulder, pain considered to be of cervical origin, neurological disorders, generalised joint inflammatory disease, or any auto-immune disease, or a corticosteroid injection into the glenohumeral joint within the previous 6 months. If suitable at this stage they were asked to attend an initial physical assessment to confirm the pain was musculoskeletal in nature and originating from the shoulder. No specific diagnosis was made because of the difficulty in differentially diagnosing shoulder problems (de Winter et al., 1999; Green, R. et al., 2008; Hegedus et al., 2008), but volunteers were included if they demonstrated a
positive Neer’s impingement test and positive Hawkins and Kennedy test, a painful arc of abduction, pain and/or weakness on manual muscle testing of the rotator cuff, and palpable tenderness over the anterior shoulder, the combination of which have been shown to correlate with SIS (Çalış et al., 2000; Cleland & Koppenhaver, 2007; Hegedus et al., 2008).

Volunteers were excluded at this stage if the shoulder pain was too severe to elevate the arm overhead, if the shoulder pain was deemed to be of cervical origin, or if any neurological or neural symptoms were present. This was determined by an experienced musculoskeletal physiotherapist through assessment of reported area of pain, evidence of sensory and motor changes in a dermatomal or myotomal distribution (Radhakrishnan et al., 1994), cervical active range of movement and passive accessory glides on the cervical zygapophyseal joints (Tampin et al., 2012). Demographics and clinical characteristics were recorded on recruitment into the study (Table 6.2).

This study was approved by the institutional Human Research Ethics Committee and written informed consent was gained from all participants prior to their enrolment into the study. All treatment was carried out in a university clinic setting.

6.2.3. Randomisation procedure

An administration assistant who had no other role in the study conducted the randomisation schedule. Single pieces of paper that identified one of the treatment groups (approximately equal numbers) were placed in sealed opaque envelopes that were shuffled and then numbered in consecutive order. At the time of the first treatment session, each participant was given a numbered envelope with content unknown to both the treating therapist and the participant until the envelope was opened.

6.2.4. Blinding

The outcome assessor was blind to group allocation and the treating physiotherapist was blind to the outcome measures.

6.2.5. Treatment

After group allocation, participants attended treatment at the university clinic once per week for 4 weeks. This schedule was elected as a pragmatic decision with consideration that local physiotherapy hospital outpatients departments work on weekly
appointments and there seems to be no consistent choice in published RCTs for a standard number of sessions per week for manual therapy and exercise over a specified time (Bennell et al., 2010; Bisset et al., 2006; Chen et al., 2009; Kachingwe et al., 2008; Yiasemides et al., 2011). Participants could take analgesics during the treatment time but were asked to refrain from seeking other forms of treatment for the duration of the study. After initial assessment, each participant was assessed and then prescribed an individualised therapeutic exercise based on that assessment and on the gold standard exercise protocol suggested by Kuhn et al (Kuhn, 2009).

6.2.5.1. Exercise Prescription

The exercise protocol included instructions on correct posture of head on neck, shoulder position and scapula position for all participants, and strengthening exercises for both the scapular stabilisers and rotator cuff muscles (Table 6.1). These exercises were individually prescribed based on the participant’s initial physical assessment. They were then progressed at the weekly treatment sessions, by either increasing the load and/or range of movement and changing position as tolerated. Participants were instructed to perform 3 sets of 10 repetitions with a one-minute rest between each set, twice per day within limits of pain. Stretches for the upper trapezius, pectoralis minor and posterior capsule were prescribed if necessary, to be performed for 30 seconds holds by 3 repetitions, 3 times per day. All exercises were recorded for the participants to take home and compliance was monitored on a Likert scale as 100% compliance, 90 - 75% compliance, 50 - 75% compliance, 50-25% compliance and to less than 25% compliance (Vagias, 2006).

**Table 6.1. Exercise Prescription**

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Prescription/ Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postural Correction</td>
<td>Specific cues – neutral lumbar spine, grow tall, scapulae back /down; head lifted off back of neck</td>
</tr>
<tr>
<td>ER in neutral with theraband</td>
<td>Elbows tucked in</td>
</tr>
<tr>
<td>Upright rows</td>
<td>Seated with theraband</td>
</tr>
<tr>
<td>IR in side lying / add weight</td>
<td>Tuck elbow in</td>
</tr>
<tr>
<td>ER in side lying /add weight</td>
<td>Tuck elbow in</td>
</tr>
</tbody>
</table>
IR/ER standing theraband/ free weight resistance progressive from neutral adduction to 90°  
Maintain scapular control

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower traps in sidelying/prone</td>
<td>Scapulae back and down</td>
</tr>
<tr>
<td>Push up plus in supine with progressive weight resistance</td>
<td>Arm 90° flexion – lift scapula around chest</td>
</tr>
<tr>
<td>Push plus in 4 pt kneeling / on elbows Progress to one arm</td>
<td>Round through chest</td>
</tr>
<tr>
<td>Wall pushes / push plus</td>
<td>Arms 90° flexion or higher</td>
</tr>
<tr>
<td>Retraining scapulohumeral rhythm</td>
<td>Specific cues – tactile / video</td>
</tr>
<tr>
<td>All exercises performed 10 x 3 sets within limits of pain twice per day</td>
<td></td>
</tr>
</tbody>
</table>

### Stretches*

<table>
<thead>
<tr>
<th>Stretch</th>
<th>Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper trapezius</td>
<td>Head forward flexed rotated to one side lateral flexed to opposite</td>
</tr>
<tr>
<td>Levator scapulae</td>
<td>Head forward flexed rotated to one side lateral flexed to same side</td>
</tr>
<tr>
<td>Pectoralis minor</td>
<td>Arm abducted 90° stretched against wall corner</td>
</tr>
<tr>
<td>Posterior capsule</td>
<td>Arm adducted across body</td>
</tr>
</tbody>
</table>

*All stretches held 30 seconds for 3 repetitions, 3 times per day

6.2.5.2. MWM-with-tape

In addition to the exercise programme participants in the multimodal treatment group received the glenohumeral MWM-with-tape each treatment session. The MWM procedure was explained to the participant prior to its application, including explanation that shoulder movement must be pain-free and that the MWM would cease immediately if any pain was experienced during the application (Hing et al., 2008; Mulligan, 2003; Teys et al., 2008). The participant was seated with an erect posture and feet flat on the floor. The plane of the scapula was determined as per the description in the outcome measures. The therapist stood on the side opposite to the affected shoulder and applied the technique as described by Mulligan (Collins et al., 2004). With one hand over the spine of the scapula posteriorly and the thenar eminence of the other hand placed over the anterior aspect of the head of the humerus, the therapist applied a posterolateral glide to
the humeral head of the affected shoulder. This was sustained while the participant raised their arm in the plane of the scapula as far as they could go or to the point of pain onset. The glide was adjusted in either a posterior or inferior direction to achieve the greatest pain free movement (Mulligan, 2004). Three sets of 10 repetitions were applied at each treatment session.

Tape was then applied to the affected shoulder. The skin was first wiped with Alco wipe and a single piece of porous hypoallergenic adhesive tape (Fixomull; Smith and Nephew, Brisbane, Australia) approximately 400 to 600 mm long and 50 mm wide, was applied to the shoulder. The participant was seated in an upright position and the tape was laid on the skin starting at the anterior aspect of the humeral head and running over the acromion and diagonally down over the scapula to a point approximately level with T7 spinal segment. The treating therapist aimed to manually position the humeral head relative to the acromion to augment the MWM manual technique, while rigid sports tape (Leukosports, Beiersdorf AG, Germany) was applied overlying the Fixomull (Figure 1). All participants were screened for tape reaction and given an education pamphlet regarding management of possible adverse reactions to tape along with instructions on how to remove the tape 48 hours’ post-application or earlier if they experienced any discomfort or adverse reaction.

6.3. OUTCOME MEASURES

Outcome measures were taken at three time points; baseline, post 4-weeks treatment, and 8 weeks’ follow-up.

The primary outcome measures were GPRI and the SPADI. Secondary outcomes were quantitative sensory measures of pressure pain threshold and heat and cold pain threshold, pain severity, and pain-free active shoulder elevation range of movement.

The GPRI was measured on a 6-point Likert scale at 4 and 8 weeks’ follow-up. Participants reported whether the shoulder pain was very much improved, much improved, improved, no change, worse or much worse. The GPRI scale has demonstrated very good test-retest reliability and correlated well with changes in upper extremity functional scales as indicative of a clinically meaningful change for patients with upper extremity limitations (Kamper et al., 2010).
The SPADI was used as a measure of shoulder function. This functional tool contains thirteen questions divided into two sub-sections. The first sub-section has 5 questions that measure pain on a scale of 0-10 where the patient is asked to circle the number that best describes their pain. The second sub-section contains eight questions where the patient rates their degree of disability on the same scale when performing tasks. The higher score indicates a greater degree of pain and disability. It is quick and easy to use and has demonstrated high validity, reliability and responsiveness to change over time (Ekeberg et al., 2010; Romeo et al., 2004; Roy et al., 2009).

Secondary outcomes included quantitative sensory measures, pain severity and range of movement. Pressure pain threshold (PPT) was measured using the Somedic Digital Pressure algometer (Somedic AB Farsta Sweden). This is a validated, reliable measure of mechanical hyperalgesia. It has been shown to have good inter- and intra-rater reliability and correlation both within and between testers on different days (Jones et al., 2007; Nussbaum & Downes, 1998; Pontinen, 1998). To optimise repeatability of the measure, the placement of the rubber tipped probe (area 1 cm²) was standardised to a point on the anterior aspect of the affected shoulder measured 5 cm distal to the anterior tip of the acromion and was held at 90° to the skin surface. This procedure differed slightly from the measurement procedures in the previous studies (Chapters 3 to 5) in an attempt to further standardise the results between outcome measures over the 4-week follow up time period. Pressure was applied at 40 kPa/sec and the participant was asked to press a button immediately when the feeling of pressure changed to a feeling of pressure with pain and/or discomfort (threshold of pain). This process was repeated three times with a 30-second rest interval between measures, and the mean was used in further analyses (Chesterton et al., 2007; Jones et al., 2007).

Cold (CPT) and heat pain threshold (HPT) were measured using the Pathway Pain and Sensory Evaluation System with an Advanced Thermal Stimulator (ATS) thermode with a surface area of 30 x 30 mm (MEDOC, Israel). Testing was in accordance with the German Research Network on Neuropathic Pain protocol (Rolke et al., 2006). It was conducted using the method of limits, whereby the participant received a graduating stimulus until the sensation was felt as discomfort/pain. This method has demonstrated reliability between testers and across days and sensitivity when screening for sensory abnormalities (Bergman et al., 2002; Kromer et al., 2013).
The thermode was placed over the anterior aspect of the affected shoulder in a similar location to the PPT. The mean of three measures was taken and used in further analysis.

Measures of current pain, resting pain and worst pain over the previous 24 hours were recorded. These were taken at each treatment session using a 0 - 100 mm visual analogue scale (PVAS), with 0 being no pain at all and 100 being the worst pain imaginable (Bijur et al., 2001). The PVAS has demonstrated reliability as a measure of pain severity and a change of 13 mm can indicate a change for the patient between a little more pain and a little less pain (Gallagher et al., 2001; McCormack et al., 1988).

Active abduction range of movement in the plane of the scapula to the point of pain onset was measured on the affected side. The plane of the scapula was defined as 30° anterior to the coronal plane. This was determined by aligning both arms of the universal goniometer along the superior border of the shoulder in the coronal plane and moving one arm forward 30° while the other arm remained in the coronal plane. A line corresponding to the alignment of the goniometer was marked on the wall with tape. The participant was then asked to elevate the affected arm along that line with the thumb pointed upward for standardisation, and asked to stop immediately upon onset of pain. This provided the patient consistency in moving the arm in the required plane. The participant’s range of arm elevation to the point of pain onset was measured with a universal goniometer in accordance with guidelines of goniometric measurement (Hayes et al., 2001). The universal goniometer has been shown to have good inter- and intra-rater reliability in patients with shoulder pathology if consistent surface anatomical landmarks are used (ICC = 0.96, 95% limits of agreement 7° (Hayes et al., 2001; Mullaney et al., 2010). The centre of the goniometer was aligned with the centre of the axis of movement of the shoulder joint posteriorly. One arm was aligned vertically parallel with the thoracic spine and the other arm along the humerus to align with the lateral epicondyle. This was in accordance with goniometric testing carried out by Hayes et al (Hayes et al., 2001). The points were marked with a permanent marker. This process was repeated three times and the mean was used in further analyses.

6.5. DATA MANAGEMENT AND STATISTICAL ANALYSIS

Data were entered into an electronic spreadsheet and intention-to-treat analyses were carried out using the Statistical Package for Social Sciences (SPSS v20.0, IBM
Inc. Chicago, USA). All participants who were enrolled into the study were included in the analysis and were analysed in the group to which they were initially allocated. As there was minimal loss to follow-up, no imputation of missing data took place.

Participant demographic and clinical characteristics at baseline were reported descriptively and independent t-tests indicated no significant differences in all measures at baseline. For continuous variables, a repeated measures two-way analysis of variance (ANOVA) was used to assess the effects of treatment over time, with time and group as the independent variables and each of the measures as the dependent variables. Alpha was set at p < .05. Post hoc calculations were carried out to establish the sample size required for a larger randomised clinical trial.

The GPRI was converted to a nominal rating of ‘success’ (1 = very much and much improved) and ‘no success’ (0 = improved, no change, worse or very much worse). Groups were then compared at 4 and 8 weeks using logistic regression.

To establish the feasibility of conducting a larger RCT effect size was estimated for all outcome measures using Glass’s delta which uses the standard deviation (SD) of the control group and is an alternative to Cohen’s d when each group has a large SD. Sample size required was then calculated from this (Ledesma & de Kohan, 2009).

6.6. RESULTS

Twenty-seven participants (17 men, 52 years, SD 11 years; 10 women 48 years, SD 12.73 years) were enrolled into the study between November 2012 and November 2013. Participant characteristics and baseline clinical characteristics are reported in Table 6.2 and the flow of participants through the study is reported in Figure 6.1. Characteristics and baseline clinical measures for three dropouts were compared to the rest of the group, and found there was no significant difference between these and baseline measures of the other participants (Table 6.2).

<p>| Table 6.2. Baseline demographics and clinical characteristics; all data presented as mean (standard deviation) unless otherwise specified |
|---------------------------------------------------------------|-----------------|-----------------|
| <strong>MWM-with-tape group</strong> | <strong>Exercise Group</strong> |
| <strong>N = 13</strong> | <strong>N = 14</strong> |
| Age, years | 53.77 (9.4) | 48.43 (12.7) |</p>
<table>
<thead>
<tr>
<th>Women, n (%)</th>
<th>5 (38.5)</th>
<th>5 (35.7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affected side dominant, n (%)</td>
<td>4 (30.8)</td>
<td>4 (28.5)</td>
</tr>
<tr>
<td>Duration of condition, months</td>
<td>14.31 (10.3)</td>
<td>13.07 (7.4)</td>
</tr>
<tr>
<td>Employment Status, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not working</td>
<td>3 (23)</td>
<td>1 (25)</td>
</tr>
<tr>
<td>Non-manual</td>
<td>3 (23)</td>
<td>5 (35.7)</td>
</tr>
<tr>
<td>Manual</td>
<td>7 (53.8)</td>
<td>8 (57.1)</td>
</tr>
<tr>
<td>Current Pain Score, mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At rest</td>
<td>21.0 (18.2)</td>
<td>33.1 (27.1)</td>
</tr>
<tr>
<td>At worst</td>
<td>55.6 (29)</td>
<td>51.8 (26.6)</td>
</tr>
<tr>
<td>ROM, degrees</td>
<td>111.9 (34.1)</td>
<td>105.14 (29.9)</td>
</tr>
<tr>
<td>CPT, °C</td>
<td>4.8 (9)</td>
<td>9.2 (11.2)</td>
</tr>
<tr>
<td>HPT, °C</td>
<td>47.61 (3.4)</td>
<td>45.26 (4.6)</td>
</tr>
<tr>
<td>PPT, kPa</td>
<td>224.1 (106.8)</td>
<td>188.6 (106.1)</td>
</tr>
<tr>
<td>SPADI</td>
<td>51.1 (20.7)</td>
<td>64.21 (18.1)</td>
</tr>
</tbody>
</table>

Abbreviations: ROM - range of movement in degrees, CPT - cold pain threshold in degrees celsius, HPT - heat pain threshold in degrees celsius, PPT - pressure pain threshold, SPADI - Shoulder Pain and Disability Index scores (0 = no pain or disability, 100 = worst pain and disability) PPT = pressure pain threshold; ROM = range of movement.

All other participants attended all sessions. One participant in the therapeutic exercise group reported increasing pain in the cervical spine and affected shoulder following the second session but it had settled by the time of the third visit. Exercise compliance was monitored across the four weeks of treatment sessions. Twenty-three of the 27 participants were greater than 75% compliant with their home exercise programme over the first week of treatment and the other four were 50-74% compliant. Sixteen participants were still greater than 75% compliant with their exercise programme by week four. Only one participant reported performing at 25% compliance because of illness in the family. This information indicates that the participants were compliant at the level that is recommended for effectiveness of an exercise programme. (Kuhn, 2009) All participants kept the tape on for the required time period with no adverse reaction reported.
There were no significant differences between groups for any of the outcome measures at baseline and follow-up (Table 6.3). There was, however, a significant effect of time within groups for all outcomes except HPT and CPT. SPADI demonstrated statistically significant improvement over time for both groups (p < 0.001). The mean improvement in SPADI for the entire sample was 25.3 points. There was an improvement in SPADI of 23.8 points for the MWM-with-tape group and 26.9 points for the exercise group after 4 weeks of treatment. This improvement was maintained in both groups (26.2 points and 25.7 points respectively) at 8 weeks’ follow-up, which indicates a clinically important improvement (Ekeberg et al., 2010). PPT (p < 0.001), PVAS (worst over 24 hours (p < 0.001) and at rest (p = 0.02), and pain-free ROM (p < 0.001) were also significantly improved over time (Table 6.4).

Table 6.3. Participant Baseline Measures
<table>
<thead>
<tr>
<th>Outcome measure</th>
<th>MWM-with-tape</th>
<th>TE</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVAS W</td>
<td>57.00</td>
<td>50.96</td>
</tr>
<tr>
<td>PVAS C</td>
<td>15.54</td>
<td>24.43</td>
</tr>
<tr>
<td>PPT A</td>
<td><strong>219.71</strong></td>
<td><strong>185.54</strong></td>
</tr>
<tr>
<td>HPT A</td>
<td>47.07</td>
<td>44.40</td>
</tr>
<tr>
<td>CPT A</td>
<td>3.93</td>
<td>10.45</td>
</tr>
<tr>
<td>ROM A</td>
<td>115.56</td>
<td>105.14</td>
</tr>
<tr>
<td>PPT UA</td>
<td><strong>233.85</strong></td>
<td><strong>223.39</strong></td>
</tr>
<tr>
<td>HPT UA</td>
<td>47.43</td>
<td>45.68</td>
</tr>
<tr>
<td>CPT UA</td>
<td>0.82</td>
<td>4.58</td>
</tr>
<tr>
<td>ROM UA</td>
<td>152.90</td>
<td>145.65</td>
</tr>
<tr>
<td>PSO 1</td>
<td>6.77</td>
<td>6.86</td>
</tr>
<tr>
<td>PSO 2</td>
<td>6.85</td>
<td>7.62</td>
</tr>
<tr>
<td>PSO 3</td>
<td>6.31</td>
<td>6.85</td>
</tr>
<tr>
<td>SPADI</td>
<td>51.15</td>
<td>64.21</td>
</tr>
</tbody>
</table>
Table 6.4. Outcomes at 4 and 8-weeks follow-up, and within-group change from baseline to each follow-up time point.

<table>
<thead>
<tr>
<th></th>
<th>MWM-with-tape Group N = 11</th>
<th></th>
<th>Exercise Group N = 13</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 weeks</td>
<td>0 to 4 weeks</td>
<td>8 weeks</td>
<td>0 to 8 weeks</td>
</tr>
<tr>
<td></td>
<td>mean (SD)</td>
<td>mean difference (95% CI)</td>
<td>mean (SD)</td>
<td>mean difference (95% CI)</td>
</tr>
<tr>
<td>SPADI</td>
<td>28.2 (26.7)</td>
<td>23 (10.6 - 35.4)</td>
<td>28.1 (28)</td>
<td>23.1 (9.66 - 36.5)</td>
</tr>
<tr>
<td>PPT, kPa</td>
<td>298.1 (143.3)</td>
<td>-73.9 (-128.9 - 19)</td>
<td>280.1 (189.6)</td>
<td>-55.9 (-126.3 - 14.4)</td>
</tr>
<tr>
<td>CPT, °C</td>
<td>6.3 (10.5)</td>
<td>-1.5 (-5.5 - 2.5)</td>
<td>7.8 (11.2)</td>
<td>-3.4 (-10.2 - 3.4)</td>
</tr>
<tr>
<td>HPT, °C</td>
<td>47.0 (4.4)</td>
<td>0.6 (-0.6 - 1.9)</td>
<td>46.2 (4.5)</td>
<td>1.4 (-0.2 - 3.0)</td>
</tr>
<tr>
<td>ROM, degrees</td>
<td>146.8 (25.2)</td>
<td>-34.9 (-54.8 - 15)</td>
<td>146.1 (28.4)</td>
<td>-34.2 (-34.2 - 58)</td>
</tr>
<tr>
<td>PVAS rest,</td>
<td>17 (17.52)</td>
<td>4.0 (-4.15 - 12.52)</td>
<td>13.14 (14.3)</td>
<td>7.86 (-4.8 - 20.5)</td>
</tr>
<tr>
<td>PVAS worst</td>
<td>40.7 (30.2)</td>
<td>14.9 (-1.4 - 31.2)</td>
<td>30.2 (30.8)</td>
<td>25.5 (3.4 - 47.5)</td>
</tr>
<tr>
<td>Success, n (%)</td>
<td>4 (36.4)</td>
<td>--</td>
<td>4 (36.4)</td>
<td>--</td>
</tr>
</tbody>
</table>

Abbreviations: SD = standard deviation; CI = confidence intervals; SPADI = Shoulder Pain and Disability Index, 0 = no pain or disability, 100 = worst pain and disability; PPT = kPa; CPT = degrees celsius; HPT = degrees celsius; ROM = degrees; PVAS = pain severity 0 mm = no pain, 100 mm = worst pain imaginable.

Success = ‘much improved’ or ‘completely improved’ on the GPI.
Sample size calculations were estimated based on the pilot study data and are illustrated in Table 6.5.

**Table 6.5. Sample size calculations for the conduct of a larger RCT**

<table>
<thead>
<tr>
<th>MWM - TE</th>
<th>PPT</th>
<th>HPT</th>
<th>CPT</th>
<th>SPADI</th>
<th>GPRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>MWM 8 wks</td>
<td>280.1</td>
<td>46.2</td>
<td>7.8</td>
<td>28.1</td>
<td>4.3</td>
</tr>
<tr>
<td>TE 8 wks</td>
<td>256.3</td>
<td>45.8</td>
<td>7.4</td>
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<td>4.2</td>
</tr>
<tr>
<td>Diff</td>
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<td>0.4</td>
<td>0.4</td>
<td>8.8</td>
<td>0.04</td>
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<tr>
<td>Baseline SD</td>
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<td>4.5</td>
<td>8.7</td>
<td>20.7</td>
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<tr>
<td>Effect size</td>
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<td>0.08</td>
<td>0.04</td>
<td>0.4</td>
<td>0.06</td>
</tr>
<tr>
<td>Sample size</td>
<td>176</td>
<td>6281</td>
<td>1571</td>
<td>100</td>
<td>6281</td>
</tr>
</tbody>
</table>

Abbreviations: MWM = mobilisation-with-movement, TE = therapeutic exercise, PPT = pressure pain threshold, HPT = heat pain threshold, CPT = cold pain threshold, SPADI = Shoulder Pain and Disability Index, GPRI = global perceived rating of improvement.

**6.7. DISCUSSION**

This randomised clinical pilot trial indicated that both groups improved in SPADI, ROM and PPT. Based on changes in SPADI, there is not sufficient evidence to warrant the conduct of a larger RCT to demonstrate the added benefit of MWM-with-tape to an exercise programme. The use of quantitative sensory measures of CPT and HPT as primary measures is not justified to identify those who may or may not respond to treatment, as seen by the unrealistically large sample sizes (N= 1571, 6281 respectively) required to reach statistical significance.

The improvement in the exercise group is consistent with reports of improvement from previous studies in terms of pain reduction and function (Hanratty et al., 2012; Littlewood et al., 2012). In a meta-analysis of six studies Hanratty et al. reported small positive effects of exercise on long term function (SMD = 0.31 (CI -0.57-0.04)).

Calculations in Table 6.5 suggest that if 220 participants (allowing for 10 dropouts per group) were included overall, exercise alone would provide a superior effect compared to an intervention of exercise plus MWM-with-tape. This suggests that there is no benefit in pursuing the effects of glenohumeral MWM-with-tape in a larger-scale RCT for people with shoulder pain. Systematic reviews have demonstrated the benefit of
adding MT to exercise but have stated that the optimal form of MT is yet to be identified (Braun et al., 2013; Camarinos & Marinko, 2009; Collins et al., 2004). It may be that alternative MWM, or a combination of MWM techniques, would be more efficacious in improving outcomes for shoulder pain, rather than employing a single MWM technique under such strict guidelines. Only one pilot RCT has attempted to establish the most beneficial type of MT for the treatment of shoulder pain. Kachingwe et al. (2008) found glenohumeral MWM and end-range mobilisations were more beneficial than mid-range passive joint mobilisations for reduction of pain at 6 weeks (Kachingwe et al., 2008). This comparative benefit however, did not reach statistical significance. MWM plus exercise was more beneficial than end range mobilisations for improvement in active ROM (Kachingwe et al., 2008). To date no large scale RCT has demonstrated the effects of pragmatically adding MWM-with-tape to exercise.

Prognostic indicators for poor response to MT include duration of symptoms and level of dysfunction at baseline as well as high levels of pain at initial presentation (Bergman et al., 2004; Braun et al., 2013; Camarinos & Marinko, 2009; Engebretsen et al., 2010; Winters et al., 1997). All participants in this study had symptoms for longer than five months which places them in the chronic shoulder pain category (Humphreys, 2011). The participant group in the current study also had low PPT measures (i.e. responded to the PPT algometer at lower thresholds) in both the affected and unaffected shoulders compared with normal values for the shoulder region (Binderup et al., 2010). However, both groups improved in PPT (i.e. had higher PPT values post interventions). This contrasts to findings in other studies. Widespread reduction in PPT values has been associated with sensitisation of the central nervous system in other conditions such as whiplash and lateral epicondylalgia, and these changes have in turn been associated with persistence of symptoms (Coombes et al., 2015; Sterling, M. et al., 2003; Sterling, M. et al., 2005). The presence of widespread hyperalgesia was not tested on the participants in this study. A study conducted on participants with lateral epicondylalgia found a subgroup of people with severe symptoms who could be distinguished by high levels of bilateral cold hyperalgesia (Coombes et al., 2012). The authors suggested that this might be a reason for poorer outcomes in response to treatment. PPT was assessed at both the affected and unaffected shoulder but not at remote regions, and it is possible that at least some of the participants exhibited signs of central sensitisation, which may have
negatively influenced treatment outcomes. Further studies should fully investigate the possibility of central sensitisation by testing the unaffected side.

The number of treatment sessions in this study may have influenced results. Other studies that reported success with MWM treated more frequently or for longer periods of time (Bisset et al., 2006; Djordjevic et al., 2012). Future studies may look at the effects of additional treatments over a longer period of time.

There was no change over time in either CPT or HPT in the current study. Sample size calculations based on CPT as a predictor for poor response to MT in people with chronic musculoskeletal shoulder pain was not feasible. Based on this pilot data, it appears that CPT and HPT cannot be recommended as outcome measures in shoulder pain populations.

The addition of tape to the glenohumeral MWM warrants discussion. It has been shown that MWM-with-tape has a longer lasting effect than MWM alone (Teys et al., 2013). It must be noted that the tape was applied after the application of the glenohumeral MWM and outcome measures taken. It remained in place for 48 hours and was then removed. It is therefore difficult to ascertain the percentage contribution of each of the techniques to improvements in outcome measures.

There is some evidence that the application of rigid tape alone as used in this study compared to sham tape can improve range of movement in the shoulder. In the study by McConnell et al. (McConnell et al., 2012; McConnell & McIntosh, 2009), shoulder ROM was only measured immediately post application of tape with no longer term follow-up. The results from other shoulder taping studies are equivocal. Bradley et al. (2009) found no changes in proprioception, or joint laxity immediately following shoulder tape application in Australian Rules football players (Bradley et al., 2009). Findings regarding other purported effects such as muscle activation are not definitive. Further investigations into effects of shoulder taping both short and long term, are warranted.

Another possible limitation of this study is the fact that one researcher screened the participants for inclusion into the study and in addition provided all treatments. In addition, only the glenohumeral MWM was applied in this study. A more pragmatic approach of including the most effective MWM (i.e. glenohumeral or scapulothoracic) or
a combination of both, that accounted for individual variation in response might yield different results, and should be considered for future studies.

6.8. CONCLUSION

This pilot clinical trial found that the conduct of a larger RCT is feasible using SPADI as an outcome measure to detect a superior benefit of an exercise programme over a combined exercise with MWM programme. Allowing for dropouts a sample size of 110 participants in each group would demonstrate a statistically significant difference between groups based on SPADI. There was no indication that the use of sensory measures of CPT and HPT could predict poor response to a glenohumeral MWM in this population. Future work should consider a more individualised, pragmatic approach to the choice of MWM technique used in interventions.
Chapter 7
Summary, discussion
and future directions
The studies in this thesis evaluated the effects of Mulligan’s MWMs on musculoskeletal shoulder pain and dysfunction, systematically exploring the tenets that Mulligan espoused the techniques should follow. Findings are synthesised and the implications for physiotherapy treatment of patients with pain limited shoulder dysfunction using both glenohumeral MWM and scapulothoracic MWM discussed. Finally, suggestions for future research are proposed.

7.1. IMMEDIATE EFFECTS OF MULLIGAN’S MWM ON PAIN LIMITED SHOULDER MOVEMENT

The first of Mulligan’s tenets is that MWM should result in an immediate improvement in pain-free joint movement (Vicenzino et al., 2011). Chapter 3 in this thesis was the first high quality within-subjects RCT (8/10 on the PEDro scale for RCTs) to provide evidence of the positive immediate effects of a single session of Mulligan’s MWM on shoulder ROM and PPT in participants with shoulder pain of musculoskeletal origin. Significant and clinically meaningful improvements in both ROM (15.3%) and PPT (20.2%) occurred immediately post application of glenohumeral MWM and the results were published in 2008 in the journal of Manual Therapy (Teys et al., 2008). At the time of the article’s publication, only one other report, published by Mulligan himself, supported the usefulness of glenohumeral MWMs for patients with shoulder pain (Mulligan, 2003). However, immediate positive effects of a single session of MWM have been found in other joints, albeit with varying success (Backonja et al., 2013; Collins et al., 2004; Hall et al., 2006; Paungmali, O’Leary, et al., 2003). The results from the first study of this thesis suggest that trialling glenohumeral MWM in a shoulder pain population is worthwhile as a first line treatment approach, particularly because none of the patients experienced any adverse response to this treatment. It must be commented that the PPT measures improved for participants in Studies One, Three and Four. Baseline measures of PPT in the participants in Study two were more 50 points higher (334 kPa) than in other studies (Study One - 310 KPa, Study 3 – 247kPa and Study Four - 219 kPa) indicating a comparatively decreased localised hyperalgesia over the affected shoulder. The pre-measures of PPT were also within normal ranges and may be an explanation for a lack of response to MWM (Binderup et al., 2010). If PPT levels at baseline were within normal ranges then treatment may not result in further improvement.

7.2. LASTING EFFECTS OF MULLIGAN’S MWM
The second study in this thesis (Chapter 4) evaluated the second of Mulligan’s tenets - that a single session of MWM should have a lasting effect in terms of improved pain-free joint range of movement (Hing et al., 2008; Hing et al., 2015; Mulligan, 2004). The results of the second study indicated that all participants experienced increased range of pain-free shoulder movement motion immediately post-treatment and for at least one week if tape was added (Teys et al., 2013). Again, prior to the publication of this study, only Mulligan had reported on the success of a single session of glenohumeral MWM (Mulligan, 2003). Mulligan treated a patient who recovered full pain-free shoulder movement following one session of glenohumeral MWM. He found this recovery had been maintained at follow-up three weeks later (Mulligan, 2003). One other study reported positive effects of a bent leg raise MWM for the treatment of low back and referred leg pain, not immediately post-treatment, but at 24 hours follow-up (Hall et al., 2006). Collectively, the findings of the first two studies of this thesis provide support for the immediate positive effects of a single session of glenohumeral MWM for improvement in pain-free shoulder movement. That is, glenohumeral MWM is a worthwhile MT technique for clinicians to trial for patients with painful shoulder movement.

7.3. ABANDONMENT OF THE SPECIFIC MWM IF UNSUCCESSFUL

Not all participants in the first study responded positively to glenohumeral MWM, defined as achieving greater than a 10° improvement in pain-free shoulder elevation range of movement (Teys et al., 2008). These results were not surprising, as not all individuals respond in the same way to a specific treatment. Mulligan espoused that if the technique chosen does not produce an immediate positive effect, then abandon the technique in favour of another treatment that might be more effective (Hing et al., 2008; Mulligan, 2004; Vicenzino et al., 2011; Vicenzino, B. et al., 2007). Mulligan followed the principle of individualising treatment based on patient response. This approach has been suggested in a publication that also espouses a similar approach to the treatment of pain limited shoulder movement (Lewis, 2009). One individual MT technique should first be applied and if one is not successful then another one trialled and finally combinations of MT techniques attempted to relieve patient symptoms. The third study in this thesis was a randomised cross-over trial conducted to investigate the immediate effects of scapulothoracic MWM in 27 participants who did not respond positively to the glenohumeral MWM. Based on the required minimal improvement of 10°, 38% of participants responded positively to the scapulothoracic MWM compared with 19% and 11% of participants who demonstrated a
positive response following sham and control interventions respectively. To date, no other studies have investigated this sequenced approach to the treatment of shoulder pain using MWMs. Future studies should take a pragmatic approach investigating combination of the glenohumeral and scapulothoracic MWMs if one or the other does not produce the desired effect of improvement in pain limited shoulder movement.

In this same study 30% of all participants did not respond to either glenohumeral or scapulothoracic MWM. Identification of individuals for whom a specific treatment approach is the most suitable is challenging in all musculoskeletal pain conditions (Chester et al., 2013; Cleland et al., 2006; Cleland & Koppenhaver, 2007; Jull et al., 2007). One explanation may be that, for people who do not respond to one MWM technique, an alternative MWM technique to attempt to change the patient’s symptoms will not further improve outcomes. There may be a currently unrecognised sub-group of people with musculoskeletal shoulder pain for whom MWM is not suitable (Cleland et al., 2006; Kent et al., 2005). It is important that health practitioners can identify individuals who are more or less likely to respond to a particular treatment approach in order to improve the clinical outcomes and cost efficiencies associated with treatments.

The fact that participants in this study had reported shoulder pain for an average of five months may have influenced outcomes. Chronic musculoskeletal pain is defined as pain that has persisted for longer than three months (Cimmino et al., 2011), and chronicity of musculoskeletal pain has been associated with a lack of response to MT treatment (Chester et al., 2013; Kuijpers, van Der Windt, et al., 2006). Another explanation may be the mechanical hyperalgesia in the participants in this study. Mechanical hyperalgesia as measured by PPT, is defined as a heightened response to normal touch (Woolf, 2011), and is thought to reflect an upregulation of the central nociceptive pathways after approximately three months’ duration of symptoms (Cimmino et al., 2011). Mechanical hyperalgesia has been associated with reduced response to treatment in other musculoskeletal conditions (Coombes et al., 2015; Jull et al., 2007). The average PPT at baseline for the participants in this study was 229 kPa in both affected and unaffected shoulders in the MWM-with-tape group and 118 kPa therapeutic exercise group, which is low compared with values on normal healthy people, reported to be around 357 kPa for men and 328 kPa for women (Binderup et al., 2010). The anomaly however is that all participants improved in measures of PPT post interventions. Further investigation such as assessment of mechanical hyperalgesia in other areas of the body, is warranted to identify
relevant characteristics of sub-groups of people with shoulder pain for whom a specific treatment approach is optimal.

Interestingly, 22% of the participants receiving the sham intervention in the third study improved in active shoulder ROM by at least 10°. There are some possible explanations for the improvements observed. Firstly, the repeated, active, pain-free movements the participants performed may have had a positive effect (Vaegter et al., 2016). Secondly, the contact of the therapist’s hands on the thoracic spine may have had some positive effect given the well-documented association between thoracic spine movement and shoulder movement (Crawford & Jull, 1993; Strunce et al., 2009; Sueki & Chaconas, 2011). Touch over the thoracic spine may also have had an influence on thoracic extension posture sufficient to influence shoulder movement (Crawford & Jull, 1993; Lewis et al., 2005).

7.4. THE ADDED BENEFITS OF TAPE

Mulligan purported that tape would augment the effects of a MWM technique (Mulligan, 2004). In clinical practice, physiotherapists frequently recommend the use of tape, particularly as an adjunct to treatment for pain relief, proprioceptive input and joint support (Vicenzino et al., 2003; Vicenzino et al., 2005). The results of the second study (Chapter 4) support the addition of tape to augment the effects of glenohumeral MWM for some individuals. Only the group that had tape applied sustained an improvement immediately post intervention in active shoulder ROM for at least one week. This “combination approach” was supported by one other clinical trial published in 2012. This study also found glenohumeral MWM-with-tape applied to the shoulder provided pain relief and improvement of movement (Djordjevic et al., 2012). However, kinesiotape was used as opposed to the rigid tape used in this thesis, and no studies to date have reported on the relative benefits of one type of tape over another for the treatment of shoulder pain. In addition, treatment by Djordjevic et al. (Djordjevic et al., 2012) was not limited to a single session, but rather, participants were treated daily over a 10-day period and measurements were taken immediately at the end of that time-period with no longer term follow-up. This limits the ability to compare studies. Other low quality evidence in the form of single case reports have supported the use of a combination of MWM-with-tape to achieve immediate reduction in pain, improved range of movement and function (O’Brien & Vicenzino, 1998; Vicenzino, B. & Wright, 1995). The mechanisms underpinning the
effectiveness of MWM-with-tape remain unclear and warrant further study. Another limitation is the fact that only one tape technique was applied. This technique was not compared to a sham or control intervention. Further research is required into comparative effects of different taping techniques on the shoulder.

The initial improvement in range of movement was due to the glenohumeral MWM but the relative contribution of the MWM versus the taping was not investigated. There is some evidence to support a biomechanical effect of tape alone on humeral head position and scapular position. Scapular taping has demonstrated effectiveness in altering scapular position and movement in patients with shoulder impingement syndrome (Shaheen, Al. et al., 2015; Shaheen, A. et al., 2013). A taping technique similar to that used in the RCTs in this thesis applied to tennis players resulted in changes in internal/external range of motion of the glenohumeral joint (McConnell et al., 2012; McConnell & McIntosh, 2009; Wang, 1999). There is high quality evidence to support a mechanical effect of tape such as an increase in medial longitudinal arch height in the lower limb (Franettovich et al., 2010a; Franettovich et al., 2008a; Vicenzino et al., 2005). It may be, therefore, that the taping technique adopted in this thesis, augmented the posterolateral glide of the MWM technique. This proposition however, is only speculative and warrants further investigation.

7.5. ADDITION OF GLENOHUMERAL MWM-WITH-TAPE TO AN EXERCISE PROGRAMME

The results of the final pilot RCT in this thesis suggest that there is no benefit in the conduct of a larger RCT to assess benefits of adding glenohumeral MWM-with-tape to an exercise programme. A priori calculations revealed that if 110 participants (including dropouts) were included per group, exercise alone would provide a superior effect compared to exercise plus glenohumeral MWM-with-tape based on SPADI, for people with shoulder pain.

Both groups demonstrated improvements in the primary outcome measures of SPADI (albeit the exercise only group demonstrated a greater mean improvement in SPADI) and GPRI and in pain-free ROM and PPT. It is interesting to note that the statistically significant improvements in SPADI and PPT found in this study contrast to findings in other studies when chronicity and severity of symptoms are considered (Jull et al., 2007; Sterling, M. et al., 2005). Participants in this pilot trial had chronic symptoms
and high levels of initial pain. Other studies have identified that these two patient characteristics often predict poorer outcomes (Jull et al., 2007; Kuijpers, van Der Windt, et al., 2006; Sterling, M. et al., 2005). The improvement in PPT is also in contrast to studies two and three in this thesis. Baseline measures of PPT in participants in Study 4 were lower than normal on both the affected and unaffected shoulders (Binderup et al., 2010), indicating the possibility of central sensitisation. Further investigations with larger sample sizes that can sub-group patients according to severity of presenting signs and symptoms and the presence of central sensitisation. This may highlight the reasons for the discrepancies between the PPT results in the studies.

There were no changes in HPT and CPT in either group in response to either treatment. The lack of change in these thermal measures pre-to post intervention is consistent with two other studies using MWMs (Collins et al., 2004; Paungmali, O’Leary, et al., 2003). It may be that these measures are not responsive to MWM (Hing et al., 2008). This finding is also supported by an investigation of QST changes pre-to post-surgery in patients with chronic shoulder pain (Valencia et al., 2012). The authors found that although pain levels improved post-surgery, HPT and CPT measures remained at pre-surgery assessment values. Speculation was that the participants with diagnosed shoulder pain requiring surgery compared with normal healthy participants with exercise-induced shoulder pain demonstrated measurable changes in central pain processing. That is, they demonstrated signs of central sensitisation (Valencia et al., 2012). Lack of response of HPT and CPT to MT such as MWM-with-tape and to exercise in this study, may also indicate the possibility of central sensitisation with chronic shoulder pain. This may be an explanation for poor response.

There is other evidence to suggest that the addition of MT in the form of joint mobilisations to an exercise programme does not confer further benefit to patients with shoulder pain (Bennell et al., 2010; Chen et al., 2009; Yiasemides et al., 2011). For example, Bennell et al. (2010) reported that “a programme of MT and home exercise did not confer additional immediate benefits in terms of pain and function compared with a placebo treatment that controlled for therapists’ contact in middle aged to older adults with chronic rotator cuff disease” (Bennell et al., 2010) p 1). The study was a large well-conducted RCT with long term follow-up. Both groups demonstrated improvements in these primary outcome measures. However, the MT group did show statistically greater
benefit at 22 weeks in SPADI. Also, the SPADI, muscle strength and self-perceived improvement favoured the treatment group (Bennell et al., 2010).

The type of MT that is used in conjunction with the exercise programme may influence the outcomes. Two studies have reported that passive mid-range shoulder joint mobilisations are not effective in reducing pain and improving movement (Kachingwe et al., 2008; Yang et al., 2007). Glenohumeral MWM plus exercise has been found to effect a higher percentage change in ROM than EOR passive mobilisations and exercise (Kachingwe et al., 2008). This study was however, a small pilot trial and although there was a trend in favour of the MWM, statistical significance was not reached (Kachingwe et al., 2008). Although EOR mobilisations and MWM both demonstrated greater improvements than mid-range mobilisations in Kachingwe’s study (Kachingwe 2008), focus was on treatment for frozen shoulder and because of this, the results may not extrapolate well to SIS. The fourth study in this thesis contributes to the current debate regarding the benefits of the addition of MWM to an exercise programme for people with shoulder pain. Results suggest that a larger RCT specifically investigating the effects of the MWM-with-tape plus exercise versus exercise alone is not warranted.

In summary, the studies in this thesis do support the positive immediate and short-term effects of glenohumeral MWM. Further investigation of the scapulothoracic MWM with a participant group that has not failed previous interventions as well as the use of a different control intervention that will not have any conflicting influence is warranted. The studies also support Mulligan’s principles that promote a patient centred clinical reasoning approach to treatment. An advantage of the MWM is that it does not necessarily require a definitive pathological diagnosis. The MWM is chosen based more on response to a client specific functional impairment that needs to be resolved and its possible immediate contribution to resolution of that impairment (Hing et al., 2008; Mulligan, 2004). The “test-application-retest feature” of MWM provides the patient and the therapist with immediate feedback on the effect of the technique.

7.6. FUTURE DIRECTIONS

Based on the findings from the studies in this thesis future research should consider the following:
7.6.1 Large scale RCT to evaluate the effects of the addition of glenohumeral MWM-with-tape to exercise.

The results of the pilot RCT do not support the feasibility of conducting a full-scale RCT with a sample size of 110 participants per group, to demonstrate superiority of MWM-with-tape and exercise over exercise alone.

Further to the above, future investigations could take a pragmatic approach to include all individual forms of shoulder MWM or combinations of the MWM’s depending on participant response. This would follow the concept of the patient-centered approach to treatment.

7.6.2 Identification of clinical characteristics of people who are less likely to respond to glenohumeral MWM

Clinical characteristics of participants who do and do not respond to glenohumeral MWM warrant further exploration. With the development of clinical prediction rules for other musculoskeletal pain disorders (Bisset & Vicenzino, 2015; Cleland et al., 2006), it is timely to explore this concept in a shoulder pain population. None of the studies in this thesis were large enough to enable analysis of treatment response of possible sub-groups of people based on such characteristics as chronicity of symptoms at presentation, severity of symptoms and baseline function. Nor was there an ability to sub-group participants with respect to response of baseline quantitative sensory measures. Evidence from other joints is that high levels of pain and thermal sensitivity predict poorer response to treatment (Bisset & Vicenzino, 2015; Coombes et al., 2012; Jull et al., 2007).

7.6.3 Comparison of glenohumeral MWM and end range passive mobilisations

There is still debate in the literature regarding the benefit of adding MT to an exercise programme for shoulder pain and dysfunction. Preliminary evidence suggests that glenohumeral MWM and end range shoulder joint mobilisations plus an exercise programme provide small but not statistically significant benefits over exercise alone (Kachingwe et al., 2008). Greater improvements in pain levels and impingement tests were reported. Glenohumeral MWM was also reported to result in a greater improvement in shoulder ROM than passive mobilisation techniques (Kachingwe et al., 2008). The Kachingwe study was however only a pilot trial with only 33 participants in total and only a trend in favour of the MWM was found. Further investigation in the form of a larger
well-designed RCT should be performed to compare the difference between these two MT techniques.

7.6.4 Investigate the possible biomechanical mechanism of effect of glenohumeral MWM

Mulligan purported that the mechanism of effect for MWM is the correction of a joint positional fault (Mulligan, 2004). This hypothesis has some support. In 2000 Hsu et al (Hsu et al., 2000) demonstrated that a caudally directed glide similar to a glenohumeral MWM improved shoulder abduction ROM albeit on 20 cadavers. Only one single case study has found successful treatment with MWM to a metacarpo-phalangeal joint injury following but no alteration of joint position when measured (Hseih et al., 2002). This study used magnetic resonant imaging (MRI)– a costly investigation that is unable to be used in a clinical setting (Hseih et al., 2002). With the emergence of the use of diagnostic ultrasound in clinical practice and its reliability with a measure of acromio-humeral distance (AHD) (Kumar et al., 2011; McCreesh et al., 2015) it is timely to investigate the possible immediate and long-term mechanical effects of the glenohumeral MWM in terms of AHD. One recent study used diagnostic ultrasound to demonstrate increase in AHD with the sustained application of an inferior manual mobilisation technique in healthy volunteers. These mobilisations were performed with the patient in supine with the arm at various positions of abduction (Witt & Talbott, 2016). The glenohumeral MWM could be applied and AHD measured post intervention in both an inferior-superior and anterior-posterior direction because of the association between these distances and shoulder impingement (Flatow et al., 1994; Graichen et al., 1999; von Eisenhart-Rothe et al., 2010; Werner et al., 2004).

7.6.5 Repeated applications of glenohumeral MWM exhibit tolerance

Glenohumeral MWM has demonstrated equivocal effects in terms of inducing a hypoalgesic response (Chapters 3, 4, 5) (Teys et al., 2008). A previous study has demonstrated that the initial hypoalgesic effect of an elbow MWM did not exhibit tolerance with repeated applications (Paungmali, Vicenzino, et al., 2003). In other words, the MWM provided positive effects at each treatment session and these effects were not reduced at each session. This feature has important clinical implications in terms of patient progression in response to a technique such as MWM. To date no studies have investigated a similar response with glenohumeral MWM. It would be beneficial to determine if
repeated applications of glenohumeral MWM exhibit tolerance or a reduced effect or if successive applications have an additive effect in terms of symptom improvement.

7.7. CONCLUSION

Pain restricted shoulder movement is the third most common musculoskeletal problem in society today and its impact is considerable in terms of both the individual's quality of life and ability to work. Shoulder pain also has a huge impact on society in terms of financial costs. Conservative treatment in the form of MT and therapeutic exercise is the most common first approach to the problem and both have been shown to be effective. There is a gold standard exercise programme recommended but the evidence for the most efficacious MT approach in terms of application parameters is still lacking. Mulligan’s MWM is a MT technique applied initially to determine immediate response in terms of alteration of patient specific symptoms. Mulligan’s MWM has a positive immediate effect on shoulder pain and range of movement and effects can last at least one week with the addition of tape. Scapulothoracic MWM has positive effects in a sub-group of people with shoulder pain for whom glenohumeral MWM is not effective. However, clinical characteristics of sub-groups who respond to either glenohumeral or scapulothoracic MWM technique have not yet been identified. A pilot trial showed that the conduct of a larger RCT is not warranted to assess benefit of the addition of glenohumeral MWM-with-tape to an exercise programme. It did not identify that the use of thermal QST measures would help to identify characteristic of people who might not respond to such a programme. Consistent with other studies’ findings these parameters did not change in a group of people with chronic shoulder pain.
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for people with shoulder pain and minimal movement restriction? A randomized controlled trial *Physical Therapy, 91*(2), 178-189.
Appendices
Appendix 1: Study 1 Ethics approval

THE UNIVERSITY OF QUEENSLAND
Institutional Approval Form For Experiments On Humans
Including Behavioural Research

Chief Investigator: Mrs Pamela Teyes
Project Title: The effects of a manual therapy technique on shoulder pain, range of movement and function
Supervisor: Dr Bill Vicenzino
Co-Investigator(s): None
Department(s): Physiotherapy
Project Number: 2004000114
Granting Agency/Degree: PhD
Duration: 1st April 2005

Comments:

Name of responsible Committee:-
Medical Research Ethics Committee
This project complies with the provisions contained in the National Statement on Ethical Conduct in Research Involving Humans and complies with the regulations governing experimentation on humans.

Name of Ethics Committee representative:-
Dr David Jenkins
Deputy Chairperson
Medical Research Ethics Committee

Date 5th March 2004
Signature [signature]
Appendix 2: Study 1 Participant Information Form

PARTICIPANT INFORMATION SHEET

TITLE: The Effects of a Manual Therapy Technique on shoulder pain, range of movement and function
LAY TITLE: The Effects of a manual therapy technique to improve pain-free range of movement of the shoulder
INVESTIGATOR: Pamela Teys MPHTY Sports B PHTY
SUPERVISOR: Dr Bill Vicenzino Senior Lecturer

The aim of this research is to assess the effects of a number of manual therapy techniques on range of movement of the shoulder. Painful limitation of shoulder movement is very common in the overhead athlete and the working population, especially those occupations that involve sustaining prolonged overhead positions.

There is some evidence that MT techniques and supervised exercise improve shoulder pain but there is no evidence of the immediate effects of a specific technique on pain and shoulder range of movement.

The treatment techniques that you will experience will involve the therapist placing his/her hands on your shoulder while you raise your arm out to the side (the exact amount will be shown to you as part of the initiation in the study. It is important that you only move your arm to the extent that is first brings on your shoulder pain.

If you participate in this study you will be required to attend our laboratory on the fifth floor of the Therapies Building (84A) on four (4) occasions. The first will involve a screening examination and familiarization session with the laboratory and the measures. It should last about 45 minutes. If you are deemed suitable for the study and you agree to be involved, then you will attend for a further three (3) sessions of approximately 30 minutes’ duration.

You will be randomly assigned to one of three (3) conditions on each of the three (3) days. You will be blinded to which of the conditions is the treatment and which is the placebo for the duration of the study.

1. Treatment (MWM)
2. Placebo
3. Control

At each of these sessions you will have pain levels and range of shoulder movement measured a number of times as well as undergoing one of the treatments.

All of the assessment will be conducted within pain limits and testing will stop as soon as you feel pain. Hence, at the worst, you should feel only pain that is momentary and you are to report any pain or discomfort to the investigator immediately you feel it.

You will have the opportunity to withdraw from the study at any time should you wish to do so without it affecting your right to treatment for your condition.

The following assessments will take place:

1. **Pain Visual Analogue Scale**: You will be asked to rate your pain on a 10cm scale – ten (10) being the worst pain and zero (0) being no pain at all

2. **Pain Pressure Threshold**: You will be asked to indicate the point at which you start to feel pain when a gradually increasing pressure is applied to a pre-determined and painful marked point on the front of your affected shoulder. A special tool will be used to measure the pressure at which you start to feel pain.

3. **Goniometric measure of shoulder range of movement**: A goniometer will be used to measure the point in your range of elevation that you start to feel onset of pain.

Your privacy while participating in this study will be maintained at all times. Your files will be kept in a locked cabinet in Physiotherapy.

Should you have any questions regarding the nature of this research, please feel free to contact me (Pam Teys ph. 33652232 or 33654523) or Dr Bill Vicenzino (ph. 33652781) and we will be happy to provide you with more information. If you would rather speak to an officer of the University not involved in this study, you may contact the Ethics Officer of the Office of Research and Post Graduate Studies, Cumbrae-Stewart Building (72) The University of Queensland 4072 ph (07) 33653924.

Thank you for your interest in this research project.

Pam Teys (Investigator)
Appendix 3: Study 1 Participant Consent Form

PARTICIPANT CONSENT FORM

TITLE: The Effects of a Manual Therapy Technique on shoulder pain, range of movement and function

LAY TITLE: The Effects of a manual therapy technique to improve pain-free range of movement of the shoulder

INVESTIGATOR: Pamela Teys MPHTY Sports B PHTY

SUPERVISOR: Dr Bill Vicenzino Senior Lecturer

1. I............................................................................................(PLEASE PRINT) hereby consent to take part in the research project.

2. I acknowledge that I have read the information sheet provided and that I have had the project, so far as it affects me, fully explained to me by the investigator. I freely consent to my participation in the project.

3. The details of the procedure proposed have also been explained to me, including the anticipated length of time it will take, the frequency with which the tests will be performed, and an indication of any discomfort or possible risks that may be expected. I understand that the tests to be taken are as follows:
   • Pre-screening physical assessment, as done in the initial consultation
   • Visual Analogue Scale Rating of Pain
   • Pressure pain threshold
   • Goniometric measurement of shoulder range of movement
   • Simple Shoulder Test

4. I understand that I will then be asked to return for three (3) sessions during the period of one week’s duration with at least 24 hours between each session to receive measurements, one of the manual handling, positioning or movement techniques at each session.

5. Although I understand the purpose of this research is to improve the quality of health care, it has been explained to me that this is a research project and not a treatment programme and my involvement may not be of direct benefit to me.

6. I am informed that no information regarding the results of any tests involving me will be published as to reveal my identity and that my privacy will be maintained at all times.
7. I understand that I am free to refuse to participate in or withdraw from the project at any stage without discrimination, reduction in level of care or any other penalty. This will not affect in any way, the management of my condition.

8. I understand that my participation in this research is voluntary and will not impact on my relationship with any of the investigators or with Griffith University;

9. I understand that if I have any additional questions I can contact the research team;

10. I understand that I can contact the Senior Manager, Research Ethics and Integrity on 07 3735 5585 or research-ethics@griffith.edu.au at Griffith University, Australia if I have any concerns about the ethical conduct of the project; and

11. I agree to participate in the project.

Signed ..........................................................................................Date .........................

(participant)

Signed ..........................................................................................Date .........................

(witness)
Appendix 4: Study 2 Ethics approval

THE UNIVERSITY OF QUEENSLAND
Institutional Approval Form For Experiments On Humans
Including Behavioural Research

Chief Investigator: Mrs Pamela Teys
Project Title: The effects of a manual therapy technique on shoulder pain, range of movement and function – 04/11/2005 – AMENDMENT
Supervisor: Dr Bill Vicenzino
Co-Investigator(s): None
Department(s): School of Health and Rehabilitation Sciences, Division of Physiotherapy
Project Number: 2004000114
Granting Agency/Degree: MPhil
Duration: 31st December 2006

Comments:

Name of responsible Committee:-
Medical Research Ethics Committee
This project complies with the provisions contained in the National Statement on Ethical Conduct in Research Involving Humans and complies with the regulations governing experimentation on humans.

Name of Ethics Committee representative:-
Dr David Jenkins
Deputy Chairperson
Medical Research Ethics Committee

Date: 01/11/05 Signature: [Signature]

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PARTICIPANT INFORMATION SHEET

TITLE: THE DURATION OF THE EFFECTS OF A SHOULDER MANUAL THERAPY TECHNIQUE AND TAPING.


INVESTIGATOR:
Pamela Teys M Physio (Sports) B Phys

SUPERVISOR:
Associate Professor Bill Vicenzino

The aim of this research is to assess the duration of the effects of a shoulder manual therapy technique on range of movement and pressure pain threshold on patients who have a painful restriction of shoulder elevation.

Should you not be suitable for the current study, you will have the option to be informed of another study and be separately consented for that study.

A recent study has shown that a specific manual therapy technique of the shoulder improves range of movement and pressure pain threshold in a patient population with painful limitation of shoulder movement. It is now intended to investigate the duration of these effects and the influence of taping on the shoulder.

The treatment technique that you will experience involves the therapist placing his/her hand on your shoulder while you raise your arm out to the side. It is important that you move your arm only to the point where you first experience your shoulder pain. Measurements will be taken before and after treatment.

Procedure

If you participate in the study you will be required to attend our laboratory on the 5th floor of the Therapies Building 54A on 7 occasions over a period of 4 weeks. The first session will involve a screening examination and familiarization session with the laboratory and the measures to be used. It should last about 45 minutes.
On Day 1 you will have measures taken and be given a treatment. Depending on your response to this treatment you will be asked to participate in this study which will include attendance for another 6 sessions.

If you do not experience an improvement in measures following the application of this particular treatment, you will be asked if you are willing to participate in another study that is investigating the immediate effects of manual contact and positioning in manual therapy technique.

On Day 1 and Day 14 you will be given a treatment consisting of manual therapy and/or tape. The sequence will be as follows:

<table>
<thead>
<tr>
<th>Day 1</th>
<th>2</th>
<th>3</th>
<th>7</th>
<th>8-14</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>21</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measures recorded</td>
<td>Measures recorded</td>
<td>Measures recorded</td>
<td>Measures recorded</td>
<td>Measures recorded</td>
<td>Measures recorded</td>
<td>Measures recorded</td>
<td>Measures recorded</td>
<td>Measures recorded</td>
</tr>
<tr>
<td>Removal of tape</td>
<td>Measures recorded</td>
<td>Measures recorded</td>
<td>Measures recorded</td>
<td>Measures recorded</td>
<td>Measures recorded</td>
<td>Measures recorded</td>
<td>Measures recorded</td>
<td>Measures recorded</td>
</tr>
</tbody>
</table>

**Measures**

The following assessments will take place:

1. **Pressure Pain Threshold**: A rubber tipped probe will be used to measure the amount of pressure required to bring on pain over a pre-determined area of your shoulder. You will be asked to indicate the point at which you start to feel pain when a gradually increasing pressure is applied to the pre-determined and marked painful anterior aspect of the shoulder. A special tool called an algometer will be used to measure the pressure at which you start to feel pain.

2. **Goniometric measure of shoulder range of movement**: A goniometer is made of plastic and is essentially a protractor with two arms that is used to measure angles between bones as joint range of motion. In this study it will be used to measure how far you can raise your arm before you feel pain. That is, it will measure the range of shoulder elevation at the point that you start to feel the onset of pain.

3. **Simple shoulder Test**: You will be asked to fill out a simple questionnaire about your shoulder pain and how it affects your daily activities.

Pre-experimental screening has indicated that you are not likely to experience an adverse skin reaction to the taping. However, it is important that you report any reaction you experience during the time the taping is on. Should this occur when you are not in the laboratory, it is recommended that you carefully remove the tape and attend to skin care as indicated in Attachment 1 of this Participant Information Sheet.

Your privacy, including information and data collected for the study will be maintained at all times. Your files will be kept in a locked cabinet in Physiotherapy.
Should you have any questions regarding the nature of this research, please feel free to contact me (Pam Teys ph 33654523/ 33652232) or Associate Professor Bill Vicenzino (ph 33652781) and we will be happy to provide you with more information. If you would rather speak to an officer of the University not involved in the study, you may contact the Ethics Officer of the Research and Postgraduate Studies, Cumbrae-Stewart Building (72) The University of Queensland 4072. Ph (07)33653924.

Thank you for your interest in this research project

Pam Teys (Investigator)
PARTICIPANT INFORMATION SHEET:
Taping Warning and Consent

Some people experience an adverse skin reaction with the application of tape. The probability of any person developing an adverse skin reaction is yet to be determined. This adverse skin reaction could include anything from a sensation of itchiness through to a complete breakdown of the skin underlying the applied tape. The consequences of a breakdown of the skin, which is the most severe form of reaction, could vary from normal healing to a delay in healing, which in the latter case if often due to an infection or ongoing irritation of the skin.

If you have any of the following adverse reactions to tape, you must immediately remove the tape using great care.

1. Itching
2. Burning
3. Pain
4. Irritable skin
5. Pins and needles / numbness in the local area or down the limb
6. Change in skin colour in the local area

REMOVE THE TAPE WITH CARE IN THE FOLLOWING WAY:
A) Pull the tape back carefully by pulling it back on itself
B) DO NOT RIP IT OFF

Not: Cream or eucalyptus oil can be used to loosen the tape prior to its removal and/or to help remove any remnants of the tape that remain on the skin.

DO NOT LEAVE THE TAPE ON ANY LONGER THAN 24 HOURS

Other Contradictions to Taping:
If you have any of the following conditions, then you will not have tape applied

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peripheral neuropathy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eczema</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any known allergy to band aids / other adhesives</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loss of sensation in the area to be taped</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor skin condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open Wounds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skin Infection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decreased Circulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Circulatory problems</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Name:............................................................Date..............................

Consent Signature: ..............................................................
PARTICIPANT CONSENT FORM

Title: The Duration of the effects of a Shoulder Manual Therapy Technique and Taping.

INVESTIGATOR: Pamela Teys M Pty St (Sports)

SUPERVISOR: Bill Vicenzino, Associate Professor

1. I …………………………………… (PLEASE PRINT) hereby consent to take part in the research project.

2. I acknowledge that I have read the information sheet provided and that I have had the project, so far as it affects me, fully explained to me by the investigator. I freely consent to my participation in the project.

3. The details of the procedure proposed have also been explained to me, including the anticipated length of time it will take, the frequency with which the tests will be performed, and an indication of any discomfort or possible risks that may be expected. I understand that the tests to be taken are as follows:

- Pre-screening physical assessment, as done in the initial consultation
- Pressure pain threshold
- Goniometric measurement of shoulder range of movement
- Simple Shoulder Test

I understand that I will then have a manual therapy application applied and have the tests taken again. If I respond in the required manner I will then be assigned to one of two groups and will possibly have tape applied.

I will then be asked to wait for ½ hour and to return again in 24 hours and one week for re-measures to be taken. I will then rest for one week and be assigned to the alternate group. The above procedures will be repeated.

4. I have completed the taping questionnaire as Attachment 1 of the Consent Form and have not ticked YES for any of the questions.

5. Although I understand that the purpose of this research is to improve the quality of health care, it has been explained to me that this is a research project and not a treatment programme, and my involvement may not be of direct benefit to me.
6. I am informed that no information regarding the results of any tests involving me will be published as to reveal my identity and that my privacy will be maintained at all times.

7. I understand that I am free to refuse to participate in or withdraw from the project at any stage without discrimination, reduction in level of care or any other penalty. This will not affect in any way, the management of my condition.

Signed: .................................................. Date: ..........................
(participant)

Signed: .................................................. Date: ..........................
(witness)
Appendix 8: Study 2 Post-experiment Questionnaire

POST-EXPERIMENTAL QUESTIONNAIRE FOR STUDY ON DURATION OF EFFECTS OF MANUAL THERAPY AND TAPPING ON THE SHOULDER

Name: ___________________________ Date: ___________________________

1. Over the course of the experiment, could you estimate whether the tapping was part of the treatment?
   No ___________________________ Yes ___________________________

2. What was the purpose of the tapping? (Circle the appropriate number).
   (i) Enhance the effect of the treatment I received at the beginning of the treatment session at which the tapping was applied.
   (ii) Inhibit the effect of the treatment I received at the beginning of the treatment session at which the tapping was applied
   (iii) No purpose during the course of the experiment.

3. Please explain why you made the choice in question 2.
   ..............................................................................................................................
   ..............................................................................................................................

4. Now that you have participated in all sessions, what do you feel the study was trying to achieve? (please circle only one number and be as accurate as possible with your choice).
   (i) The study was testing the duration of the effects of a manual therapy technique to improve pain and range of movement in the shoulder.
   (ii) The study was testing the duration of the effects of a manual therapy technique and tapping together to improve pain and range of movement in the shoulder.
   (iii) The study was testing the difference in duration of the effects of manual therapy and manual therapy and tapping over a period of the experiment.
   (iv) The study was testing the effects of pain measures and range of movement measures over a period of time with manual therapy and tapping.
   (v) I am unsure of the exact nature of the study’s objectives.

4. What is the reason for your response to question
   ..............................................................................................................................
   ..............................................................................................................................

THANK YOU FOR YOUR INVALUABLE CONTRIBUTION TO THE PROJECT
Appendix 9: Study 3 Ethics Approval

To Whom it May Concern

Human Research Ethics Approval
“The effects of a manual therapy technique on shoulder pain, range of movement and function”
(Ref: PES/29/10/HREC)

I am pleased to advise that this research has approval to commence from the Griffith University Human Research Ethics Committee, a committee established and operating in accordance with the standards and principles of the Australian National Statement on Ethical Conduct in Human Research (2007) and Griffith University policy.

The decision to approve is dated 5 January 2011 and covers the period 18 January 2011 to 31 December 2013.

For any queries regarding this ethical approval please contact the Committee Secretary on 3735 4375 or research-ethics@griffith.edu.au.

Yours sincerely,

Rick Williams
Secretary to the Griffith University Human Research Ethics Committee and Manager, Research Ethics and Integrity
Office for Research
Griffith University
Nathan Qld 4111 Australia

31 March 2015
Appendix 10: Study 3 Participant Information Sheet

School of Physiotherapy and Exercise Science
Griffith University, Gold Coast

PARTICIPANT INFORMATION SHEET

TITLE: The Effects of a manual therapy technique to improve pain-free range of movement in the shoulder

Chief Investigator: Dr Leanne Bisset
Student Researcher: Pamela Teys

School of Physiotherapy and Exercise Science
Griffith University, Gold Coast
Ph: 07 5527717
Email: l.bisset@griffith.edu.au

School of Physiotherapy and Exercise Science
Griffith University, Gold Coast
Ph: 07 55954462
Email: p.teys@griffith.edu.au

The aim of this research is to assess the effects of manual handling, positioning and movement of the shoulder on pain and range of movement of the shoulder. Health care workers such as physiotherapists often use positioning and manual handling techniques of the shoulder along with exercises to help manage shoulder pain.

The basis by which you will be selected

Inclusion criteria
You may be included in the study if you are aged 18 to 65 years and have:
- pain in the anterolateral aspect of your shoulder that is limiting your ability to lift your arm overhead
- This must have been present for more than 6 weeks to allow for natural healing.

Exclusion criteria
You will be excluded from the study if you have:
- A history of cancer
- Any auto-immune disease
- Rheumatoid arthritis / inflammatory disease
- Any infection around the shoulder
- Any recent fractures, dislocations or recent surgery around the shoulder
- Any neurological disorders

If you participate in the study you will be required to attend the Griffith University School of Physiotherapy and Exercise Science on four (4) occasions. The first will involve a screening examination and familiarisation with the staff, laboratory and the measures. It should take about 45 minutes. If you are deemed suitable for the study and you agree to be involved, then you will be asked to attend a further three (3) sessions of approximately 30-45 minutes’ duration. At each of these sessions you will experience one of the following conditions:

- Manual handling, positioning and movement of the shoulder blade A
- Manual handling, positioning and movement of the shoulder blade B
- Movement of the shoulder blade

You will experience all of these techniques at some time during your involvement in the study. The order in which you will experience them will be randomised.

At no stage should you feel pain during these sessions, as the first onset of pain is the end point of all tests and procedures. That is, you are to stop any movement or test that you are undertaking at the point that you feel the first onset of pain. The therapist will stop applying the manual handling, positioning and movement at that stage as well.

Remember: You are to indicate when you first feel pain on any test or procedure in the experiment. Pain must not last longer than that of the first onset during any test of procedure. If you have any ongoing pain or discomfort after an experimental procedure you must report this to the study investigator immediately.

You will have the opportunity to withdraw from the study at any time should you wish to do so without affecting the right to treatment for your condition.

The following tests and procedures will take place before and after the manual handling, positioning and movement procedures listed above:

**Pain Visual Analogue Scale:** You will be asked to rate your pain on a 10cm line. This scale has the words ‘no pain’ at the 0cm end of the line and ‘worst pain imaginable’ at the other end.

**Pressure Pain Threshold:** You will be asked to indicate by pushing a button the point at which you start to feel pain when a gradually increasing pressure is applied to the pre-
determined and marked painful anterior aspect of your shoulder. A special tool will be used to measure the pressure at which you start to feel pain.

_Goniometric measure of shoulder range of movement:_ A goniometer will be used to measure the point in your range of elevation that you start to feel onset of pain.

**Expected benefits of the research**

This project will help to compare the relative benefit of one type of manual handling and positioning technique over another. The results of this study may be helpful in developing more effective treatment approaches for people with shoulder pain. Directly, as a participant, you will be provided with advice from an experienced clinician on self-management strategies.

**Risks to you**

All tasks will be performed pain-free and should you experience any pain during the tasks, we will stop testing immediately. You will be referred to the on-site health professional for further assessment and/or treatment, at no cost to you. There are no risks within this study that are any greater than those experienced in everyday living.

**Your confidentiality**

Data will be recorded either on printed data collection forms or electronically through specialised computer software. All data will then be transferred into an electronic database and will be kept confidential and secure in a locked cabinet of a private office for hard copy information and by restricted password for computerised information. Once the study is complete and you have received your results, your name will be removed from the data, to keep the information anonymous.

**Your participation is voluntary**

Whether you decide to participate in the study or not, your decision will not prejudice you in any way. If you do decide to participate, you are free to withdraw at any time and your data will also be withdrawn from the study.

**Funding**

There will be no financial gain as a result of this study for any of the research investigators.
Questions / further information

We are happy to answer any queries you may have at this time. If any aspect of the study concerns you, or if you just have general questions, please do not hesitate to contact the chief investigator, Pam Teys on 07-55954462 (mobile 0410047796) (p.teys@griffith.edu.au) or Dr Leanne Bisset Ph: +61 7-5552 7717 Email: lbisset@griffith.edu.au.

The ethical conduct of this research

Griffith University conducts research in accordance with the National Statement on Ethical Conduct in Human Research. If potential participants have any concerns or complaints about the ethical conduct of the research project they should contact the Senior Manager, Research Ethics on 3735 5585 or research-ethics@griffith.edu.au at Griffith University, Australia.

Feedback to you

Everyone who participates will be provided with a report detailing your individual results for each test as well as the group averages test results as soon as they are available. Data obtained through completion of this project will be submitted to a peer reviewed journal. You will be informed when these results are published.

Further Information

This study forms part of the Student Researcher’s academic programme (Doctor of Philosophy)

Privacy statement

The conduct of this research involves the collection, access and/or use of your identified personal information. The information collected is confidential and will not be disclosed to third parties without your consent, except to meet government, legal or other regulatory authority requirements. A de-identified copy of this data may be used for other research purposes. However, your anonymity will at all times be safeguarded. For further information, consult the University’s Privacy Plan at www.griffith.edu.au/ua/aa/vc/pp or telephone (07) 3735 5585.

Thank you for your interest in this research project.
Pam Teys (Investigator)
Appendix 11: Study 3 Participant Consent Form

The Effects of manual therapy handling, positioning and movement to improve pain-free range of movement in the shoulder

PARTICIPANT CONSENT FORM

<table>
<thead>
<tr>
<th>Investigator</th>
<th>Pamela Teys</th>
<th>Supervisor</th>
<th>Dr. Leanne Bisset</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>School of Physiotherapy and Exercise Science</td>
<td>School of Physiotherapy and Exercise Science</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Griffith University, Gold Coast</td>
<td>Griffith University, Gold Coast</td>
</tr>
<tr>
<td>Ph:</td>
<td>+61 7-</td>
<td>Ph: +61 7-5552 7717</td>
<td>Email: <a href="mailto:p.teys@griffith.edu.au">p.teys@griffith.edu.au</a></td>
</tr>
<tr>
<td>Email:</td>
<td><a href="mailto:p.teys@griffith.edu.au">p.teys@griffith.edu.au</a></td>
<td>Email: <a href="mailto:l.bisset@griffith.edu.au">l.bisset@griffith.edu.au</a></td>
<td></td>
</tr>
</tbody>
</table>

I...........................................................................................................(PLEASE PRINT) hereby consent to take part in the research project.

I acknowledge that I have read the information sheet provided and that I have had the project, so far as it affects me, fully explained to me by the investigator. I freely consent to my participation in the project.

The details of the procedure proposed have also been explained to me, including the anticipated length of time it will take, the frequency with which the tests will be performed, and an indication of any discomfort or possible risks that may be expected.

I understand that the tests to be taken are as follows:

- Pre-screening physical assessment, as done in the initial consultation
- Visual Analogue Scale Rating of Pain
- Pressure pain threshold
- Goniometric measurement of shoulder range of movement
- Simple Shoulder Test
I understand that I will then be asked to return for three (3) sessions during the period of one week’s duration with at least 24 hours between each session to receive measurements, one of the manual handling, positioning or movement techniques at each session.

Although I understand the purpose of this research is to improve the quality of health care, it has been explained to me that this is a research project and not a treatment programme and my involvement may not be of direct benefit to me.

I am informed that no information regarding the results of any tests involving me will be published as to reveal my identity and that my privacy will be maintained at all times.

I understand that I am free to refuse to participate in or withdraw from the project at any stage without discrimination, reduction in level of care or any other penalty. This will not affect in any way, the management of my condition.

I understand that my participation in this research is voluntary and will not impact on my relationship with any of the investigators or with Griffith University;

I understand that if I have any additional questions I can contact the research team;

I understand that I can contact the Senior Manager, Research Ethics and Integrity on 07 3735 5585 or research-ethics@griffith.edu.au at Griffith University, Australia if I have any concerns about the ethical conduct of the project; and

I agree to participate in the project.

Signed ............................................................Date .............................................

(participant)

Signed

............................................................Date.............................................

(witness)
Appendix 12: Study 4 Ethics Approval

Research Administration - Ethics (Protocol Number FES/34/12/HREC)

Please send the requested documents. The attachment status to research ethics

Louise Green
Dear Gery, Thank you for the response and thank you for the ethics committee

Gery Mar p.s. p.m@prh.edu.au

In January I outlined 9 issues u776912

Dear Louise

Many thanks for your email and the information. The corresponding guidelines have been addressed. Once we received the signed first approval, all the remaining issues you email will be addressed by the end of the week.

Best regards

Gery

Dr Gary Allen
Director, Ethics Research & Integrity
Office for Research
School of Health Science
Camperdown, NSW
Tel.: 02 9351 3555
Fax: 02 9351 3664
www.adelaide.edu.au

FAIDS. RIGHTS AND CONSENTS

The work and any /the participation of the persons included in the study is the responsibility of the researchers. No one shall be identified by name or code in any publication or presentation. Any information that identifies or could identify the patient or research subject will not be included in the analysis or reported or otherwise made public. The names of the researchers are not to be included in the analysis or reported in the publication.
PARTICIPANT CONSENT FORM

Project title: The Effects of a therapeutic exercise programme plus or minus manual handling and tape for painful restriction of shoulder movement and function

Lay project title: The Effects of a therapeutic exercise programme plus or minus manual handling and tape for painful restriction of shoulder movement and function

Investigator: Pam Teys
Chief Investigator
School of Physiotherapy and Exercise Science
Griffith University, Gold Coast
Ph: 07-36237689
Email: pam.teys@griffith.edu.au

Leanne Bisset PhD
Supervisor
School of Physiotherapy and Exercise Science
Griffith University, Gold Coast
Ph: 07-5552 7717
Email: l.bisset@griffith.edu.au

Why is the research being conducted?

The aim of this research is to investigate the optimal conservative approach to the treatment of patients with shoulder pain. There is evidence to demonstrate that exercise alone is better than a wait and see approach and also that one treatment session of a specific manual therapy and tape improves movement in people with shoulder pain.

It is hoped that information gathered from this project will help to contribute to knowledge of an optimal conservative treatment approach to shoulder pain that limits a person’s ability to carry out many activities of daily living and to participate in work and sport.

What you will be invited to do

You will be invited to attend five sessions of up to one (1) hour each, at the Australian Catholic University’s Health Clinic located on the Banyo campus. Initially a physiotherapist will take you through a physical examination to see if you are suitable for the project. If you are deemed to be suitable and you are willing to participate, you will
undergo a series of measurements and then be randomly allocated to one of two treatment groups:

Therapeutic exercise plus a home exercise programme

Therapeutic exercise plus manual handling and tape and a home exercise programme

You will undergo your first treatment and measurements will be repeated. You will then be asked to return at approximately the same time each week for another three (3) weeks to have exercises progressed and/or another session of manual therapy and tape. Finally, you will be asked to return for a final follow-up session for final measurements to be taken.

Measurements:

Prior to commencement of testing, the following series of measures will be taken by an assessor:

*Questionnaires and visual analogue scales (VAS):* Using scales or multiple choice answer questionnaires, age, hand dominance, history of shoulder complaints, employment type, severity of pain, level of arm function, and impact on occupational and recreational activities will be measured.

*Pressure pain threshold:* Using an electronic pressure algometer, the amount of pressure that provokes the first onset of pain will be measured over the site on the shoulder that is most tender to palpation.

*Heat pain threshold:* Using an electronic heat pain sensor (a small device (2 cm x 2 cm x 2 cm cube) that will be fixed to your shoulder using double-sided sticky tape and Velcro and attached to a computer) the amount of heat you can tolerate up to the first onset of pain will be measured.

*Cold pain threshold:* Using an electronic cold pain sensor (as above) the same device will be plugged into a computer and will give a reading of the amount of cold you can tolerate to the first onset of pain.

*Active range of shoulder movement:* A goniometer will be used to measure the point in your range of elevation that you start to feel onset of shoulder pain.

The basis by which you will be selected
**Inclusion criteria**

You may be included in the study if you have been experiencing shoulder pain for a minimum 4 weeks’ duration which is provoked or increased by elevating your arm and if you are aged 18 to 65 years.

**Exclusion criteria**

You will be excluded from the study if you have any recent shoulder dislocation, any recent fractures around the shoulder, systemic illnesses such as rheumatoid arthritis, if are in the acute phase of adhesive capsulitis, if your shoulder pain is deemed to be originating from your neck and if you have a neurological impairment, osteoporosis, haemophilia and/or malignancies. You will also be excluded if you have had any treatment of your shoulder pain by a health care practitioner within the last six weeks and/or a corticosteroid injection to your shoulder joint in the last six months.

**Expected benefits of the research**

This project will help to provide knowledge regarding the most effective conservative approach to the treatment of shoulder pain. Directly, as a participant, you should gain benefit from both approaches as both have been shown to be effective in relieving pain and improving shoulder movement.

**Risks to you**

All tasks will be performed pain-free and should you experience any pain during the tasks, we will stop testing immediately. You will be referred to a health professional for further assessment and/or treatment, at no cost to you. The manual technique will also be performed only to the onset of pain. If there is any pain experienced with your home exercise programme you must stop immediately and contact the Chief Investigator.

**Your confidentiality**

Data will be recorded either on printed data collection forms or electronically through specialised computer software. All data will then be transferred into an electronic database and will be kept confidential and secure in a locked cabinet of a private office for hard copy information and by restricted password for computerised information. Once the study
is complete and you have received your results, your name will be removed from the data, to keep the information anonymous.

**Your participation is voluntary**

Whether you decide to participate in the study or not, your decision will not prejudice you in any way. If you do decide to participate, you are free to withdraw at any time and your data will also be withdrawn from the study.

**Questions / further information**

We are happy to answer any queries you may have at this time. If any aspect of the study concerns you, or if you just have general questions, please do not hesitate to contact Pam on the contact details which are displayed on the front of this page.

**The ethical conduct of this research**

Griffith University conducts research in accordance with the National Statement on Ethical Conduct in Human Research. If potential participants have any concerns or complaints about the ethical conduct of the research project they should contact the Manager, Research Ethics on 3735 5585 or research-ethics@griffith.edu.au.

**Feedback to you**

Everyone who participates will be provided with a report detailing your individual results for each test as well as the group averages test results as soon as they are available. Data obtained through completion of this project will be submitted to a peer reviewed journal. You will be informed when these results are published.

**Privacy statement**

The conduct of this research involves the collection, access and/or use of your identified personal information. The information collected is confidential and will not be disclosed to third parties without your consent, except to meet government, legal or other regulatory authority requirements. A de-identified copy of this data may be used for other research purposes. However, your anonymity will at all times be safeguarded. For further information, consult the University’s Privacy Plan at www.griffith.edu.au/ua/aa/vc/pp or telephone (07) 3735 5585.
Thank you for your interest in this research project.

Date: ______________________________

Name ________________________________ Signed _____________________

Witness _________________________________ Signed _____________________
Appendix 14: Study 4 Initial phone screening form.

**INITIAL PHONE SCREENING FOR SHOULDER STUDY**

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where is your pain?</td>
<td>Have you dislocated your shoulder?</td>
<td>How long have you had the pain?</td>
<td>Do you suffer any neck pain that you think may be related to your shoulder pain?</td>
</tr>
<tr>
<td>Front/back/side of shoulder or upper arm (please circle)</td>
<td></td>
<td>Usual severity of pain over past week (rate 0-10 scale)</td>
<td>Do you have rheumatoid arthritis?</td>
</tr>
<tr>
<td>Have you dislocated your shoulder? When?</td>
<td></td>
<td>Worst pain over the past week (rate 0-10)</td>
<td>Do you have any auto-immune disease? (fibromyalgia, chronic fatigue)</td>
</tr>
<tr>
<td>Do you suffer any neck pain that you think may be related to your shoulder pain?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Usual severity of pain over past week (rate 0-10 scale)</td>
<td></td>
<td>Do you have any pins % &amp; needles or numbness down the arm?</td>
<td></td>
</tr>
<tr>
<td>Worst pain over the past week (rate 0-10)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>What caused your shoulder pain? (Accident/injury/sport/work/activity/nothing)</td>
<td></td>
<td>Have you had any fractures around the shoulder?</td>
<td>How is your general health?</td>
</tr>
<tr>
<td>Have you had any fractures around the shoulder?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This is some more information regarding the shoulder study. This should help you to see if you fit the criteria for my study and to see if you could afford the time to participate.

If you are eligible you would be asked to attend the Physiotherapy and Health Centre, Level 2 in the Clinical Sciences Building GO2 for a further 2 sessions. The first session is a further physical screening test to see if you fit the criteria. It takes approximately 45 minutes. Pam Teys
## PRE-SCREENING FORM FOR SHOULDER PAIN SUBJECTS

<table>
<thead>
<tr>
<th>Date</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td></td>
</tr>
<tr>
<td>DOB</td>
<td></td>
</tr>
<tr>
<td>Contact Details</td>
<td></td>
</tr>
<tr>
<td>Shoulder Affected</td>
<td></td>
</tr>
<tr>
<td>Dominant Hand</td>
<td></td>
</tr>
<tr>
<td>Length of time of signs and symptoms</td>
<td></td>
</tr>
<tr>
<td>Onset of Current symptoms</td>
<td></td>
</tr>
<tr>
<td>Triggering Incident</td>
<td></td>
</tr>
<tr>
<td>Past History</td>
<td></td>
</tr>
<tr>
<td>Previous Treatment</td>
<td></td>
</tr>
<tr>
<td>Investigations</td>
<td></td>
</tr>
<tr>
<td>Medications</td>
<td></td>
</tr>
<tr>
<td>General Health</td>
<td></td>
</tr>
</tbody>
</table>

### SUBJECTIVE EXAMINATION:

Do you have any of the following conditions?

<table>
<thead>
<tr>
<th>Condition</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>History of Cancer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fractures around shoulder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diagnosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>Rheumatoid arthritis/joint inflammatory disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neurological disorder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auto-immune disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infection around shoulder</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Do you suffer neck pain that you think may be related to your shoulder?

Do you have any arm pain /pins and needles/weakness in the affected arm?

Do you have any feeling of instability in your shoulder?

Have you had any recent shoulder surgery or a dislocation within the past 3 months?

**PHYSICAL EXAMINATION**

Observations

Cervical AROM

Flexion:

Extension:

<table>
<thead>
<tr>
<th>Lateral Flexion (Right)</th>
<th>Lateral Flexion (Left)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rotation (Right)</th>
<th>Rotation (Left)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cervical PAIVMs
Pain: On a scale out of 10, 10 being the worst pain that you can imagine, and 0 being no pain at all, where on the scale would you rate your pain
At rest:
At worst:
Night:

**Shoulder AROM**

<table>
<thead>
<tr>
<th>Flexion (right):</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extension:</td>
<td>Left</td>
</tr>
<tr>
<td>Abduction (Right)</td>
<td>Abduction (Left)</td>
</tr>
<tr>
<td>Internal Rotation (Right)</td>
<td>Internal Rotation (Left)</td>
</tr>
<tr>
<td>External rotation (right)</td>
<td>External rotation (left)</td>
</tr>
<tr>
<td>Palpation</td>
<td></td>
</tr>
</tbody>
</table>
Appendix  16: Initial Assessment Sheet for all Shoulder Studies

Initial Assessment for Shoulder Study

<table>
<thead>
<tr>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject Name</td>
</tr>
<tr>
<td>DOB</td>
</tr>
<tr>
<td>Contact (W)</td>
</tr>
<tr>
<td>Contact (Home)</td>
</tr>
<tr>
<td>Email</td>
</tr>
<tr>
<td>Shoulder Affected</td>
</tr>
<tr>
<td>Hand Dominance</td>
</tr>
<tr>
<td>Length of time symptoms present</td>
</tr>
<tr>
<td>Onset current symptoms (triggering incident)</td>
</tr>
<tr>
<td>Past History</td>
</tr>
<tr>
<td>Previous Treatment</td>
</tr>
<tr>
<td>Investigations</td>
</tr>
<tr>
<td>Medications</td>
</tr>
<tr>
<td>General Health</td>
</tr>
</tbody>
</table>
Physical Assessment

Do you have any of the following conditions?
Cancer
Rheumatoid Arthritis / inflammatory disease
Neurological Disorder
Auto-immune Disease
Infection around the shoulder

2. Do you suffer neck pain that you think is related to your shoulder pain?

3. Do you have any arm pain/ pins and needles / numbness/ weakness?

4. Do you have any feeling of instability in your affected shoulder?

Have you had a recent dislocation of your shoulder?

Observations

_________________________________________________________________________

_________________________________________________________________________

Cervical AROM
Flexion_____________________________
Extension____________________________
Lateral Flexion(R) ______________________________
Lateral Flexion(L)____________________________
Rotation(R)____________________________
Rotation(L)____________________________

Cervical PAIVM’s

_________________________________________________________________________

Shoulder

Pain Rating:
VAS (at rest) __________________________
VAS (Worst)____________________________
VAS (past 24 hours) __________________________
Night pain? __________________________
Sleeping Position

**Shoulder AROM**

<table>
<thead>
<tr>
<th></th>
<th>Right</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extension</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abduction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scaption</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal rotation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>External rotation (Neutral)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>External rotation at 90° abduction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HBB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand behind Head</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palpation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Body Chart
Appendix 17: Griffith University Induction form

RHD Induction Quiz

CERTIFICATE OF COMPLETION

Congratulations Pam Teys,

You have successfully completed your RHD Induction!

Wishing you all the best in your research studies at Griffith University.

Printed 30-Dec-2011 16:04

Receipt Number 6D3D21C6

You can close this window now.

[Close Window]
Appendix 18: Baseline Measures of Pain Study 3.

PVAS

<table>
<thead>
<tr>
<th>Baseline Pain (mm)</th>
<th>Treatment A</th>
<th></th>
<th>Treatment B</th>
<th></th>
<th>Treatment C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>rest</td>
<td>worst over 24hrs</td>
<td>current</td>
<td>rest</td>
<td>worst 24 hrs</td>
</tr>
<tr>
<td>AVG</td>
<td>13.06</td>
<td>43.15</td>
<td>12.36</td>
<td>15.74</td>
<td>37.80</td>
</tr>
</tbody>
</table>