Effect of myofascial release to the chest on glenohumeral internal rotation: A comparison of practitioner-applied vs self-applied techniques

Amanda Kate Smythe

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Declaration

Name of candidate: Amanda Kate Smythe

This Thesis/Dissertation/Research Project entitled 'Effect of myofascial release to the chest on glenohumeral internal rotatio: A comparison of practitioner-applied vs self-applied techniques' is submitted in partial fulfilment for the requirements for the Unitec degree of Master of Osteopathy.

Candidates Declaration:

I confirm that:

- This Thesis/Dissertation/Research Project represents my own work;
- Research for this work has been conducted in accordance with the Unitec Research Ethics Committee Policy and Procedures, and has fulfilled any requirements set for this project by the Unitec Research Ethics Committee.
  Research Ethics Committee Approval Number: 2012-1099

Candidate Signature: Date:

Student number: 1318405

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List of Symbols & Abbreviations

CI	Confidence Interval (95% unless stated otherwise)
°	Degrees
df	Degrees of freedom
D	Depth
d	Effect size (Cohen's *d*)
r	Effect size for independent *t*-tests
H	Height
hr	Hour
ICC	Intraclass correlation coefficient
JBMT	Journal of Bodywork and Movement Therapies
mm	Millimetre
MDC	Minimal detectable change
ROM	Range of motion
n	Sample size
s	seconds
SMR	Self-myofascial release
SD	Standard deviation
SEM	Standard error of measurement
p	Statistical Probability
t	T-test
W	Width

Introduction to Thesis

The glenohumeral joint relies on the support of surrounding soft tissue structures for stability (Cooper et al., 1993; McFarland, 2006). When the muscles and fascia that are anatomically related to the glenohumeral joint become dysfunctional, this can lead to changes in the mechanics and range of motion (ROM) of the joint (Borsa et al., 2000). People who regularly perform overhead movements are at risk of functional loss of range in the glenohumeral joint, in particular internal rotation range (Dwelly et al., 2009; Ludewig & Borstad, 2003; Wilk et al, 2009a).

Clinically it has been suggested that myofascial release to the soft tissues of the chest is effective in improving glenohumeral ROM when applied by a practitioner, or alternatively, when applied by the patient (Starrett, 2011), however, there is little research in the area. Active patient care, such as self-myofascial release (SMR) has been clinically observed to improve active ROM and avoid pain development (Cook, 2010). However, little research is available to support the effectiveness of SMR and there appear to be no studies in relation to the glenohumeral joint. The aim of the research aspect of this project was to conduct a preliminary investigation into the effectiveness of myofascial release to the chest on glenohumeral internal rotation. Additionally the study aimed to compare the effectiveness of practitioner-applied and self-applied techniques.

This thesis is arranged into three sections. Section 1 is a review of the literature regarding reduced glenohumeral internal rotation range and the affected populations; myofascial dysfunction and myofascial release technique; and the value of self-applied techniques. Section 2 contains a manuscript formatted in accordance with submission requirements of the *Journal of Bodywork and Movement Therapies* (JBMT) [Appendix D Instructions for Authors]. Section 3 (Appendices) contains other material supplementary to the thesis.

Section 1: Literature Review

Introduction to the Literature Review

This review begins with an overview of myofascial dysfunction in the shoulder, its impact on range of motion (ROM), and populations that are likely to be affected by a reduction in range. An overview of the glenohumeral joint, its normal range and accepted methods of measuring ROM for research purposes is included. The literature is then reviewed to give an overview of the current understanding and recent developments within the area of myofascial dysfunction. This section will review literature from the basic and applied science fields and will discuss how the findings have led to the current clinical use of myofascial techniques by physical therapists. In particular the focus will be on the clavipectoral fascia as this is suggested to impact on glenohumeral internal rotation and is the focus of the research project in Section 2. Finally this review considers patient-centred care and active care, its role in physical therapy, and how myofascial release can form part of this model of patient care.

The literature search for this review was performed using online databases: Science Direct, EBSCO host, PubMed (Medline). The combinations of keywords included: shoulder, glenohumeral joint, chest, upper limb, range of motion, internal rotation, fascia, myofascial, myofascial release, myofascial compression, manual therapy, physical therapy, osteopathy, physiotherapy, patient-centred care and active care.

Shoulder dysfunction

The shoulder is a complex multiaxial structure that relies on the surrounding muscles for support and stability ahead of the bones and ligaments, as in most other joints (Cooper et al., 1993; McFarland, 2006). Therefore dysfunction in the muscles, or fascia that overlies the muscles, will impact on the integrity of the joints that comprise the shoulder. The complex nature of the function of the shoulder girdle means that it can be difficult to precisely determine mechanisms of dysfunction (Horsley, 2005). It has been noted clinically that the presence of myofascial dysfunction can lead to articular dysfunction in the corresponding joints, thought to be due to soft tissue restriction that is maintained by a positive feedback loop from the central nervous system (Lewit, 2010; McPartland & Simons, 2006). Dysfunction in myofascial structures surrounding the shoulder joints can lead to a complex array of symptoms. Little is known about treatment of these structures and its effect on pain and shoulder function (Bron et. al., 2007).

Shoulder dysfunction and pain is a common cause of musculoskeletal morbidity (Roquelaure et al., 2006). A systematic review of the literature by Luime et. al. (2004) reported that point prevalence of shoulder pain ranges between 6.9% and 26% and is a significant contributor in limiting activities of daily living. A key contributor to limiting the shoulder's ability to perform activities is reduced range of motion. It is suggested that abnormal mechanics in the glenohumeral joint, one of the components of the shoulder complex, is an important risk factor for shoulder pathologies such as impingement and bursitis (Levangie & Norkin, 2001). It would therefore stand to reason that addressing abnormal function and mechanics prior to the development of pain would be useful for a large number of people. Reduced glenohumeral internal rotation has been identified as giving overhead athletes an increased risk of shoulder pathologies (Buckhart et al., 2003), however, limited research exists to address this dysfunction.

Normal internal rotation range

Internal rotation of the shoulder is considered to be completely glenohumeral motion as opposed to other movements of the shoulder that involve the sternoclavicular, acromioclavicular and scapulothoracic joints (Kelley & Clark, 1995). The normal internal rotation range for the shoulder is generally considered to be between 0 and 70 degrees when measured with the arm abducted to 90 degrees (AAOS, 1965; Boone & Azen, 1979; Hurd et al., 2011; Kibler et al., 1996). However age-related decreases in mobility have been noted. According to Boone & Azen (1979) and Roy et al. (2009) age-related decreases can become more apparent from age 60 onwards. A higher prevalence of shoulder problems has been observed in advancing age groups, particularly beyond 60 years of age (Bjelle, 1989). The previously aforementioned studies typically use age 20 as the lower limit for adults as this is accepted age at which skeletal maturity is reached. No statistically significant differences for glenohumeral internal rotation between males and females have been noted in the literature, however variations in soft tissue composition between genders has been demonstrated. The sex hormones estrogen and relaxin have been found to impact on the elasticity of connective tissues and are thought to be the reason for differences in muscle and ligament composition (Hewett et al., 2007; Negishi et al., 2005; Park et al., 2009). Hormonal variations and their effect on connective tissues suggest that a difference in ROM between genders is possible and future studies should take this into account.

Who is affected by limited glenohumeral internal rotation?

Repetitive overhead movements of the shoulder have been identified as a significant risk factor for functional loss of range of motion particularly internal rotation (Lintner et al., 2007; Ludewig & Borstad, 2003). The populations most affected by these issues are construction workers and those involved in throwing sports (Dwelly et al., 2009; Ludewig & Borstad, 2003; Wilk et al., 2009a). Many studies have demonstrated that in overhead athletes there is greater external rotation range in the dominant arm with a corresponding loss of glenohumeral internal rotation in pain free individuals (Baltaci et al., 2001;

Barnes et al., 2001; Crocket et al., 2002; Ellenbecker et al., 2002; Osbahr et al., 2002; Sauers et al., 2014). It is suggested that this alteration in shoulder mechanics translates to an increased risk of shoulder pathologies in overhead athletes (Buckhart et al., 2003). The pathologies that such athletes are suggested to have greater risk of developing include SLAP lesions, secondary impingement, partial rotator cuff tears, internal impingement and pain (Aldridge et al., 2012; Burkhart et al., 2003; Jobe & Pink, 1996; Wilk et al., 2011).

Although several authors have suggested that shortening of the soft tissues in the chest can contribute to limitation of internal rotation at the glenohumeral joint (Lintner et al., 2007; Stecco et al., 2007), currently little literature exists to support effective therapeutic interventions to improve the loss in ROM. Dwelly et al., (2009) suggest that techniques to improve the internal rotation lost with repetitive throwing in sport will improve shoulder function and overall athlete performance. An intervention to improve glenohumeral internal rotation would be useful in preventing pain and improving performance, which has the potential to save resources and increase productivity.

Reduced functional range without pain

Individuals who seek care from a manual therapist may have musculoskeletal function without pain as a dominant feature in the clinical picture (Cook, 2010). Recreational and professional sports people are a population who commonly require increased function, including range of motion, to improve their overall performance (Dwelly et al., 2009). In previous myofascial release studies, participants with pain related symptoms have been included (Ajimsha, 2011; de las Penas et al., 2005; Hains & Hains, 2010; Montanez-Aguilera et al., 2010). However, participants with clinical signs that indicate reduced functional ROM represent a population that are suggested to be at increased risk of developing overuse injury and musculoskeletal pain (Cook, 2010; Kiesel et al., 2013; Lehr, 2013; O'Connor et al., 2011) and may be under-researched. It is thought that decreased functional range is due to the inconsistent relationship between pain and motor control responses (Hodges, 2001; Hodges & Mosely, 2003;

O’Sullivan, 2005). Although the focus of this review is not painful populations, it is worthwhile considering that pain modifies nervous system outputs and can lead to altered muscle function, which will reasonably affect joints and their associated ROM.

Measurement of glenohumeral internal rotation

According to Ellenbecker et al. (2002), internal and external rotation measurements of the shoulder are conventionally performed with stabilisation of the scapulothoracic joint to isolate the glenohumeral joint. The findings of Wilk et al. (2009b) support this method of measurement because they determined that stabilising the scapula during passive internal rotation measurement (as opposed to stabilising the humeral head or having no stabilisation) has the highest intra-rater reproducibility. The authors recommend that scapular stabilisation be used to allow normal glenohumeral arthrokinematics, while supporting and stabilising the scapulothoracic articulation.

In terms of recording ROM measurements, a review of five methods for assessing shoulder ROM, determined that still photography has fair-good reliability and is comparable to goniometry (Hayes et al., 2001). The study recommends that when photography is used for data collection that two prominent landmarks are identified and marked to provide a reference point. For the purpose of research, still photography is useful because it provides the opportunity for blinding and randomisation for data extraction and analysis.

Conflicting evidence exists to support the decision to measure active or passive ROM in therapeutic intervention studies. However, active ROM is the variable that is clinically useful and recent research supports its use. It has been demonstrated that increases in passive ROM do not necessarily translate to improvements in active function (Moreside & McGill, 2013). This finding supports the use of active measures in therapeutic intervention studies.

Myofascial Structures

There has been increasing interest in myofascial basic and applied science (Chaitow, 2011). The field has only a small body of research and much of the information in this field remains theoretical rather than evidence based. Physical therapists have become particularly interested in these recent developments and the role that fascia plays in musculoskeletal disorders. The following section is designed to give an overview of the current state of evidence in the field of myofascial science.

Fascia is a connective tissue with a three-dimensional structure that extends throughout the entire body, surrounding muscles, bones, organs and nerves (Langevin, 2006; LeMoon, 2008, Myers, 2008; Schleip, 2003; Stecco, 1996). The fascial structure consists of cells, mostly fibroblasts, in addition to elastin microfibrils, interstitial fluid and ground substance, which includes hyaluronic acid (Reed et al., 2010). Fibroblasts are the primary cell in fascia and they have been found to integrate, arrange, and remodel collagen, depending on the tension between the cell and the extracellular matrix (Grinnell, 2008). It has been demonstrated in areola connective tissue that remodeling can occur within minutes, both *in vivo* and *ex vivo* (Langevin, 2011). Fibroblasts are also known to produce and degrade matrix proteins and have an indirect effect on matrix stiffness by differentiating into myofibroblasts, which can contract and increase tension of the tissue (Grinnell, 2008). The ability of fibroblasts to transform into myofibroblasts demonstrates a reason for the slight contractibility of fascia.

Advances in medical diagnostic imaging allows tissue to be investigated at a cellular level and has therefore allowed greater investigation of the effects of externally applied forces, in the form of manual therapy, on tissues such as fascia. Langevin et al. (2011) demonstrated that by inhibiting fibroblast activity, connective tissue tension is increased. Therefore fibroblasts have been identified as an important factor in modulating the viscoelastic properties of fascia.

Fascial connections have been demonstrated on a body-wide scale, however, connections also exist at the cellular level and they have the potential to have widespread effects. It has been demonstrated that mechanical pressure on a cell surface can cause nucleus expansion and lead to DNA transcription (Ingber, 2007). This means that the cells can transfer external mechanical stress into internal biochemical reactions, which is important for manual therapists to be aware of.

One of the important functions of fascia is to separate structures and allow for tissue excursion (Bhattacharya et al., 2010; van der Wal, 2009). Guimberteau et al. (2005; 2010) demonstrated the gliding ability between all structures below the skin using *in vivo* dissections of the wrist. It is thought the sliding ability is present in all fascial tissues within the body (Findley, 2011). At the junction between fascia and muscle is a lubricating layer of hyaluronic acid, which allows sliding between adjacent structures (McCombe et al., 2001). Hyaluronic acid has been shown to play an important role in viscosity changes of the ground substance (Stecco et al., 2011). The extracellular ground substance directly affects fluid flow due to the presence of hyaluronic acid in the interstitial matrix (Reed et al., 2010). Hyaluronic acid is osmotically active and causes swelling, however, the extracellular matrix fibres restrict swelling and reduce the fluid retaining capacity of the ground substance. Manual therapy such as myofascial release has been shown to increase hyaluronic acid levels (Roman et al., 2013) and is thought to increase blood flow to the area, which provides the opportunity for the ground substance to draw fluid from local capillaries and restore the viscosity (Barnes, 1996). Decreased viscosity may reduce the resistance of fascia and muscle layers to glide over one another (Findley, 2011). However, these claims currently have no supporting evidence and only recently have technological advancements allowed for preliminary investigations into tissue excursion (Guimberteau et al., 2005; Guimberteau et al., 2010; Yoshi et al., 2009).

While the biochemical effects of mechanical stress on the cells within fascia appear to occur within minutes (Langevin, 2011), the tissue has also been demonstrated to undergo changes with longstanding stress. Fascia is remodeled in response to the demands placed on it (Kjaer, 2009). At a molecular (Mosler, 1985) and macroscopic level (Sasaki and Odajima, 1996) the connective tissue reorganises itself along lines of tension in response to mechanical stress over long periods of time. Changes in collagen can eventually result in the formation of cross-links between fibres (Fratzl 2008), which is thought to alter the viscoelastic properties of fascia and contribute to myofascial dysfunction. Tissue remodeling has been shown to occur in tendons, ligaments and joint capsules and if this process also occurs in fascia it could provide a body-wide pattern for remodeling based on movement and local tissue stress (Langevin, 2006).

Physical therapy techniques that aim to improve myofascial dysfunction, have their hypothetical concepts drawn from the histologic evidence of fascial responses to stress and mechanical deformation. Clinically, fascia has been identified as an important element to be considered in regard to general musculoskeletal dysfunction as it extends throughout the entire body and has intimate connections with the muscles that allow joint movement (Stecco et al., 2007). Excessive mechanical tension in fascial structures in one region within the body is thought to affect mechanically related regions due to the anatomical continuity of myofascial connections (Myers, 2008).

Clavipectoral fascia and dysfunction

The clavipectoral fascia is a thin layer of connective tissue that has many elastic fibers within it and is firmly attached to the muscle beneath it (Stecco et al., 2009). It has been suggested that myofascial (muscle, tendon and other connective tissue) tension in the chest can limit internal rotation of the glenohumeral joint (Lintner et al., 2007; Starrett, 2011). According to Barnes (1997) fascial restrictions can lead to strain patterns that alter joint alignment, producing dysfunction such as loss of range of motion and in some cases pain.

This fascia is thought to be under strain and tender to palpate when glenohumeral internal rotation is reduced (Stecco et al., 2007). When fascia is functioning normally the adjacent surfaces slide against one another (Stecco et al., 2011). However, when the density of the fascia changes, as has been suggested to occur with ongoing stress in the clavipectoral region, the behaviour of the fascia changes. The change makes it more difficult for the surfaces to slide over one another and the result is reduced mobility in corresponding joints (Stecco et al., 2011). The clavipectoral fascia is richly innervated and tension in this region would give rise to tender areas on palpation (Stecco et al., 2007).

Clinically, it has been proposed that myofascial compression applied to the soft tissues of the chest can improve internal rotation of the shoulder (Starrett, 2011). The target tissue of this technique is the clavipectoral fascia, which overlies and adheres to the pectoral muscles of the chest (Stecco, 2009).

Myofascial release as a therapeutic technique

The term ‘myofascial release’ refers to a group of therapeutic manual therapy techniques that aims to improve function in dysfunctional muscles and their corresponding fascia. The name myofascial release is somewhat ambiguous and a more appropriate name to describe the technique would be myofascial compression, however the literature rarely refers to it in this way. Myofascial release is a technique widely used by musculoskeletal therapists that is intended to reduce adhesions and optimise the sliding ability of fascia in acute and chronic situations (Barnes, 1996). Myofascial release involves mechanically deforming the shape of fascial and connective tissues by applying manually delivered forces against a collagenous barrier for between 90 and 120 s until palpable change in tissue texture is detected by the practitioner (Manheim, 2001; Montanez-Aguilera et al., 2010). It is often necessary to repeat these steps more than once to achieve clinical benefit (Manheim, 2001). A study by (Ercole et al., 2010) reported that different periods of time were required to modify apparent fascial density, depending on the length of time the subject had symptoms: in subjects with symptoms present for less than 3 months (sub-acute) the average time myofascial release had to be performed before the tissues released was less (2 min, 35 s) than the time it took with chronic patients (3 min, 17 s). This would suggest that one intervention is adequate to potentially observe a clinical change.

One way that myofascial release is thought to be beneficial is due to a reduction in strength of cross-links between collagen fibers and therefore adhesions, leading to an improved ability of fascial layers to slide over one another (Martínez Rodríguez & Galán del Rio, 2013). A study by Standley and Meltzer (2008) showed that myofascial release could influence intracellular biochemistry and enhance cytokine secretions to give the improved range of motions and pain reduction that is seen post-treatment.

It is important to recognise that, while the initial mechanical models to support the mechanism of myofascial release have literature to support them, flaws exist in this theory. Research suggests that the force applied by manual therapists may not be adequate enough to cause significant collagen deformation (Martínez Rodríguez & Galán del Rio, 2013). However, alternative models are being investigated, including a neurophysiological approach. The discovery of the presence of mechanoreceptors in fascia (Stecco et al., 2007) was important because it means that myofascial release can potentially be used to stimulate these receptors, leading to altered afferent inputs to the central nervous system and a response that relaxes contractile fibres. Although much investigation is needed to further support the neurophysiological model, it is a concept that should be considered when using myofascial release.

Myofascial release to the chest

Few studies have investigated the effectiveness of myofascial release techniques on measurable patient outcomes such as range of motion (Weiselfish-Giammatteo & Kain, 2005). Research in musculoskeletal therapy commonly uses pre- and post-measurement of range of motion as an outcome reference although to date there has not been any studies reporting changes in internal rotation at the glenohumeal joint following application of myofascial techniques. Montanez-Aguilera et al. (2010) suggested that although evidence exists to support the clinical use of myofascial release, randomised controlled trials should be conducted to explore the effectiveness.

A technique demonstrated by Starrett (2011) is suggested to achieve improvements in glenohumeral internal rotation. The technique can be performed in two ways: 1) One version of the technique is administered by the practitioner; and 2) the alternative is for the participant to perform the technique to themselves after simple instruction. Starrett (2011) breaks the self-administered technique into three parts, each part involving greater mechanical loading on the targeted tissues. The technique can be graded from ‘mild’ to ‘very strong’ depending on patient tolerence. No research investigating this specific application of the technique described by Starrett (2011) has been conducted to date. Similar myofascial techniques have been studied in regard to trigger points in the chest, however, due to the lack of inter-rater reliability for trigger point diagnosis there are limitations to these studies (Lucas et al., 2009). There have been calls in the literature for investigators to use more objective measurements to document changes observed in response to therapeutic myofascial compression techniques (Weiselfish-Giammatteo & Kain, 2005).

In practice, myofascial compression is said to be useful because it does not require any equipment, is generally well tolerated by patients and is not physically demanding on the practitioner (Hains, 2002). The benefit of myofascial compression as described by Starrett (2011) is that it could be performed by the patient at home, in addition to (or as an alternative to) treatment received in a clinic. The technique has the potential to improve rate of recovery and act as a preventative tool. It has been suggested that for individuals at risk of functional losses and disability due to shoulder pathologies, an at home exercise routine would decrease long term pain and functional losses in the shoulder (Ludewig & Borstad, 2003).

Patient centred care

Patient centred care is a widely accepted concept among medical professions. The concept supports active patient involvement in decisions regarding their care and requires health professionals to take into account individual patient's values and preferences (Bloom, 2002; Mead & Bower, 2002). The use of a patient centred model promotes a high locus of control, self-efficacy and empowers patients by giving them some responsibility in terms of their health care (Ellis, 1999; Mead & Bower, 2002). Patient centred care complements the use of evidence based practice, which integrates the best available research, clinical experience and patient values (Sackett et al., 1996). Evidence supports a patient centred approach to healthcare and can have benefits including improved satisfaction, adherence and outcomes (Stewart, 1995).

Active care

Active patient care, which has an emphasis on active movement-based interventions, is a model that places importance on patient recovery, re-introduction to activity and self-management. An active treatment approach may include advice, exercise prescription, delivery of manual therapy, or a combination that is appropriate for the individual, with the aim of restoring function (Liebenson, 2006). Clinical authors have suggested that active movement based interventions are appropriate for individuals with reduced function, such as a ROM deficit, prior to the development of pain related symptoms (Boyle, 2010; Cook, 2010). Active therapeutic interventions are aligned with a patient-centred approach as they allow the patient to be better engaged with their treatment and are suggested to improve outcomes (Liebenson, 2006). Active forms of treatment, as opposed to passive treatment, are said to have longer lasting effects due to the enhanced engagement of the neuromuscular system, which includes efferent muscle activity and muscle recruitment (Lederman, 2010).

History of self myofascial release

Self myofascial release could be considered as a form of prescribed therapeutic exercise and is therefore consistent with an active approach to patient care. Self myofascial release has had increased interest and use in the last decade, however, research to support its use is focussed on foam rollers as an applicator tool and is typically focussed on the lower limb (Healy et al., 2014; Okamoto et al., 2014). Foam rolling is thought to contribute to pre-exercise tissue preparation as part of athlete warm-ups (Boyle, 2010) and is suggested to provide potential improvement in post-exercise recovery rates (Healy et al., 2014). It is also suggested that improved myofascial mobility could be useful for injury prevention (Boyle, 2010; Kjaer et al., 2009), although this hypothesis requires further investigation. The concept of targeting fascia in performance oriented strength and conditioning programs is a recent addition to the traditional focus on muscular strength, cardiovascular fitness and neuromuscular coordination (Schleip & Muller, 2013). Further research to support myfascial release will likely lead to greater acceptance of the value in incorporating such techniques into athletic training programs.

A study by Okamoto et al. (2014) has shown that self myofascial release (SMR) using a foam roller is effective in both reducing arterial stiffness and improving vascular endothelial function. This effect is thought to be the reason that foam rolling promotes flexibility and post-workout recovery. The findings by Okamoto et al. (2014) support the use of myofascial compression to improve shoulder flexibility. In addition to this, the foam roller demonstrates the current successful use of a self myofascial release tool. Several studies have found that foam rolling is useful for increasing corresponding joint range of motion, without impacting on the force that a muscle is able to generate (MacDonald, 2013; Sullivan, 2013). Given the benefits to range of motion and the low cost of self myofascial release, it would be useful to investigate applications in other body regions. MacDonald et al. (2013) found that a single, two minute application of SMR to the quadriceps resulted in an increase in knee flexion by up to 11 degrees. These promising findings suggest clinically meaningful improvements in range with a single technique application.

Prescribed therapeutic exercise

Many prescribed exercises do not appear similar to the manual therapy techniques on which they are based. The SMR technique described by Starrett (2011), to improve glenohumeral internal rotation, looks similar to the technique that a practitioner might use in clinic. If the self-applied technique can be used to achieve similar benfits to the practitioner-applied version, this could usefully be prescribed in certain clinical situations. Prescribed exercise for patients to perform unsupervised typically has low compliance (Bendermacher et al., 2006). Literature supports the use of prescribed exercise in combination with manual therapy, which has been demonstrated in people with neck pain (Masaracchio et al., 2013; Miller et al., 2010), shoulder pain (Grant et al., 2004; Kromer et al., 2009) and chronic low back pain (Geisser et al., 2005; Hayden et al., 2005). However, it is also widely accepted that compliance for unsupervised exercise is low. In some cases compliance is reported to be as low as 30% (Beinart et al., 2013; Schneiders, 1998). Supervised SMR minimises compliance issues while allowing patients to receive the benefits of an active treament.

Conclusion

The literature does provide biological rationale to explain the effects of myofascial techniques in clinical use. There is currently no published research reporting the effects of SMR on glenohumeral ROM. Previous studies investigating the effect of practitioner-applied myofascial release on glenohumeral ROM have used a trigger point approach. Research has shown that there are problems with the reliability of trigger point diagnosis (Lucas et al., 2009) and the generalisability of these studies is therefore limited. There is a need for preliminary investigations into the effectiveness of myofascial release on glenohumeral ROM. Additionally it would be useful to have a comparison of practitioner-applied and self-applied myofascial release techniques.

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Section 2: Manuscript

Note: This manuscript has been written in accordance with the instructions for authors for the *Journal of Bodywork and Movement Therapies (JBMT)* [See Appendix D for Guide for Authors]. It is suggested that tables and figures are placed in a separate document, rather than throughout the body of work. For ease of reading for the examination process this guideline has not been adhered to. References to appendices, placed in square brackets throughout the manuscript, are also for examination purposes and are not intended for manuscript submission.

Effect of myofascial release to the chest on glenohumeral internal rotation: A comparison of practitioner-applied vs self-applied techniques

Effect of myofascial release to the chest on glenohumeral internal rotation: A comparison of practitioner-applied vs self-applied techniques

Author: Amanda Kate Smythe BAppSc(HB)

Affiliation: Department of Osteopathy
Unitec New Zealand
Private Bag 92025
Auckland
New Zealand

Contact: Email: asmythe@live.com
Tel: +64 9 815 4321
Fax: +64 9 815 4573

ABSTRACT

Effect of myofascial release to the chest on glenohumeral internal rotation: A comparison of practitioner-applied vs self-applied techniques

Background: Limitation of glenohumeral internal rotation is a common finding in people who regularly perform overhead movements during sporting and vocational tasks. **Aim:** The aim of this preliminary randomised controlled experiment was to investigate the effect of myofascial release (practitioner-applied *vs* self-applied) to the chest on glenohumeral internal rotation. **Methods:** Healthy, physically active, male participants (n=10; mean 30.7±5.9 years) with reduced glenohumeral internal rotation (deemed to be due to myofascial dysfunction), and with tenderness reported on deep palpation of the chest, were enrolled. Participants were randomised to a practitioner-applied (n=5) or self-applied (n=5) technique intervention group. Active glenohumeral internal rotation ROM measurements were recorded prior to, immediately following, 1 hr post, and 24 hr post-intervention. **Results:** The main finding was an immediate, clinically meaningful, and statistically significant increase in glenohumeral internal rotation for the treatment limb compared to the control limb that was retained 24 hr after intervention (pre to 24 hr post-intervention: mean difference±SD = -6.94±3.24°, 95% CI -9.25 to -4.63°, t=-6.8, df=9, $p \leq 0.001$). There was no significant difference in ROM change between the practitioner-applied treatment limb group and the self-applied treatment limb group (pre to 24 hr post-intervention: mean difference±SE = 3.38±3.3°, 95% CI -4.21 to 10.98°, t=1.027, df=8, p=0.334). **Conclusion:** Therapeutic myofascial release to the chest was associated with a clinically meaningful improvement in glenohumeral internal rotation. Additionally, the magnitudes of effect for both practitioner-applied and self-applied myofascial release were similar. Given the clinically favorable effects observed in this small sample, a larger randomised controlled study is warranted.

MeSH key words: Manual Therapies; Massage Therapy; Upper Extremities; Bodywork; Joint, Shoulder; Joint Range of Motion

1. INTRODUCTION

Limitation of glenohumeral internal rotation is a common finding in people who regularly perform overhead movements during sporting and vocational tasks (Dwelly et al 2009; Ludewig & Borstad 2003; Wilk et al 2009). Although a functional reduction in internal rotation range may not be associated with pain, these individuals are thought to be at risk of developing shoulder pathology (Aldridge et al 2012; Burkhart et al 2003; Jobe et al 1996; Wilk et al 2011). It has been suggested that myofascial (muscle, tendon and other connective tissue) tension in the chest may contribute to limitation of internal rotation at the glenohumeral joint (Lintner et al 2007; Stecco et al 2007). Clinically, it has been observed that therapeutic myofascial compression applied to the chest, and targeted to the clavipectoral fascia, can improve glenohumeral range of motion (ROM) (Starrett 2011). The clavipectoral fascia overlies and adheres to the pectoral muscles of the chest (Stecco 2009) and is involved in the function of the glenohumeral joint (Cooper et al 1993).

The fascial system is a body-wide connective tissue that invests structures including the musculoskeletal, nervous and circulatory systems (Langevin 2006; LeMoon 2008; Myers 2008; Schleip 2003b; Stecco 1996). The composition of fascia includes collagen to provide structure and stability, and elastin to allow flexibility (Langevin & Huijing 2009). Myofascial release, a manual therapeutic technique, has been indicated for use in addressing musculoskeletal dysfunction of myofascial origin (Remvig et al 2008). The main aim of myofascial release is to improve fascial extensibility (Schleip 2003a) and improve the ability of layers to slide against one another (Stecco et al 2011).

Active patient care is a model that emphasizes recovery, re-introduction to activity and self-management, with the goal of restoring function. An active approach may include advice, exercise prescription, delivery of active manual therapy, or a combination that is appropriate for the individual (Liebenson 2006). Individuals who seek care from a manual therapist may have musculoskeletal dysfunction without having pain as a dominant feature in the clinical picture (Cook 2010). Several clinical authors have suggested that active movement based interventions are more appropriate for this population than passive treatment (Comerford & Mottram 2001; Comerford & Mottram 2012; Cook 2010; Lederman 2009; Sahrmann 2010). The benefits of active movement based interventions include potentially longer lasting effects than passive treatment due to the engagement of the neuromuscular system that causes muscle recruitment and efferent muscle activity (Lederman 2010). Self-myofascial release (SMR), a form of active care, has become an increasingly common (Healey et al 2014; Okamoto et al 2014) way to address myofascial dysfunction. The use of SMR techniques have the potential to improve rate of post-exercise recovery (Healy et al 2014), and have been used to prepare tissue prior to exercise (Boyle 2010). It has been suggested that for individuals at risk of functional losses and disability due to shoulder pathologies, an at home exercise routine would decrease long term pain and functional losses in the shoulder (Ludewig & Borstad 2003). Dwelly et al (2009) suggest that techniques to improve the impaired glenohumeral internal rotation associated with repetitive throwing in sport (Kibler et al 2012) can improve shoulder function and overall athlete performance.

Despite emerging research interest in foam rolling as a form of SMR, there appears to be no previous studies investigating alternate methods of SMR. In particular, no research investigating the specific application of SMR to the chest has been published to date. Practitioner-applied myofascial techniques affecting the chest have previously been studied using a trigger point approach (de las Peñas et al 2005; Hain & Hains 2010; Montanez-Aguilera 2010), however, there are inherent problems in generalizing these findings given the well-established limitation in reliability of trigger point palpation (Lucas et al 2009). In light of clinical observations that myofascial release can improve functionally reduced glenohumeral internal rotation, and combined with the lack of supporting evidence, there is a clear need for further investigaton. Therefore, the aim of this randomised controlled experiment was to undertake a preliminary investigation of the effect of myofascial release to the chest on glenohumeral internal rotation. Additionally, this study was designed to enable the efficacy of practitioner-applied and self-applied myofascial release techniques to be compared.

2. METHODS

2.1 Participants

Participants were recruited from the local community using word of mouth and email notices distributed within a tertiary educational institution. Interested applicants were provided with an information sheet [See Appendix A] and invited to attend a consultation where they were informed of the study procedures and screened to determine their eligibility to participate. Those that were eligible gave written informed consent [See Appendix B]. The study was approved by the institutional research ethics committee (UREC Approval 2012-1099) [See Appendix C].

2.1.1 Inclusion criteria

For inclusion it was necessary for participants to: i) be healthy, physically active males, aged 20 to 55 years; ii) have at least 20% less than the normal glenohumeral internal rotation range (less than 56°) when the shoulder is abducted to 90° (AAOS 1965; Boone & Azen 1979; Hurd et al 2011; Kibler et al 1996); iii) on palpation the researcher had to be satisfied that the end ROM felt ‘elastic’, suggestive of myofascial joint restriction, as opposed to a ‘boney’ or other end feel (Tozzi 2012); iv) report tenderness on deep palpation over the chest, adjacent to the coracoid process. For cases in which both left and right shoulders satisfied the inclusion criteria, the side with the most limited glenohumeral internal rotation was used for the study. In all cases the participant’s alternate shoulder was used as a control.

2.1.2 Exclusion criteria

The therapeutic techniques chosen for this study are indicated when pain or dysfunction in the shoulder is reasoned to be of myofascial origin (McPartland & Simons 2006). Therefore, exclusion criteria were intended to exclude people whose ROM impairment was associated with previous trauma or medical condition. Exclusion criteria were: i) a history of previous shoulder surgery; ii) presence of known rheumatological, neurological, orthopaedic, or other neuromusculoskeletal conditions such as adhesive capsulitis, rotator cuff pathology, cervical radiculopathy, diabetes mellitus, cancer, muscular or connective tissue pathologies; iii) recent trauma to the shoulder; and iv) presence of current shoulder pain other than tenderness on palpation.

2.2 Design

The study was designed as a single-blinded, randomised controlled experiment in which participants were randomly allocated to a practitioner-applied or self-applied intervention group (see Figure 1). Block randomisation was employed to ensure equal group size (Herbert 2005). Randomisation was administered by an independent assistant using an online service (http://random.org). The researcher was blinded to group allocation until data analysis. The research assistant who undertook all measurement procedures was blinded to group allocation in an attempt to control for expectation bias. Additionally, the measurement assistant was blinded to the identity of the participants by masking the participants' face and body with fabric drapes during data collection procedures. The independent variables were: intervention group (practitioner-applied or self-applied); limb (treatment or control); time (pre-intevention, immediately post-intervention, 1 hr post-intervention, 24 hr post-intervention). The dependent variable was glenohumeral internal rotation.

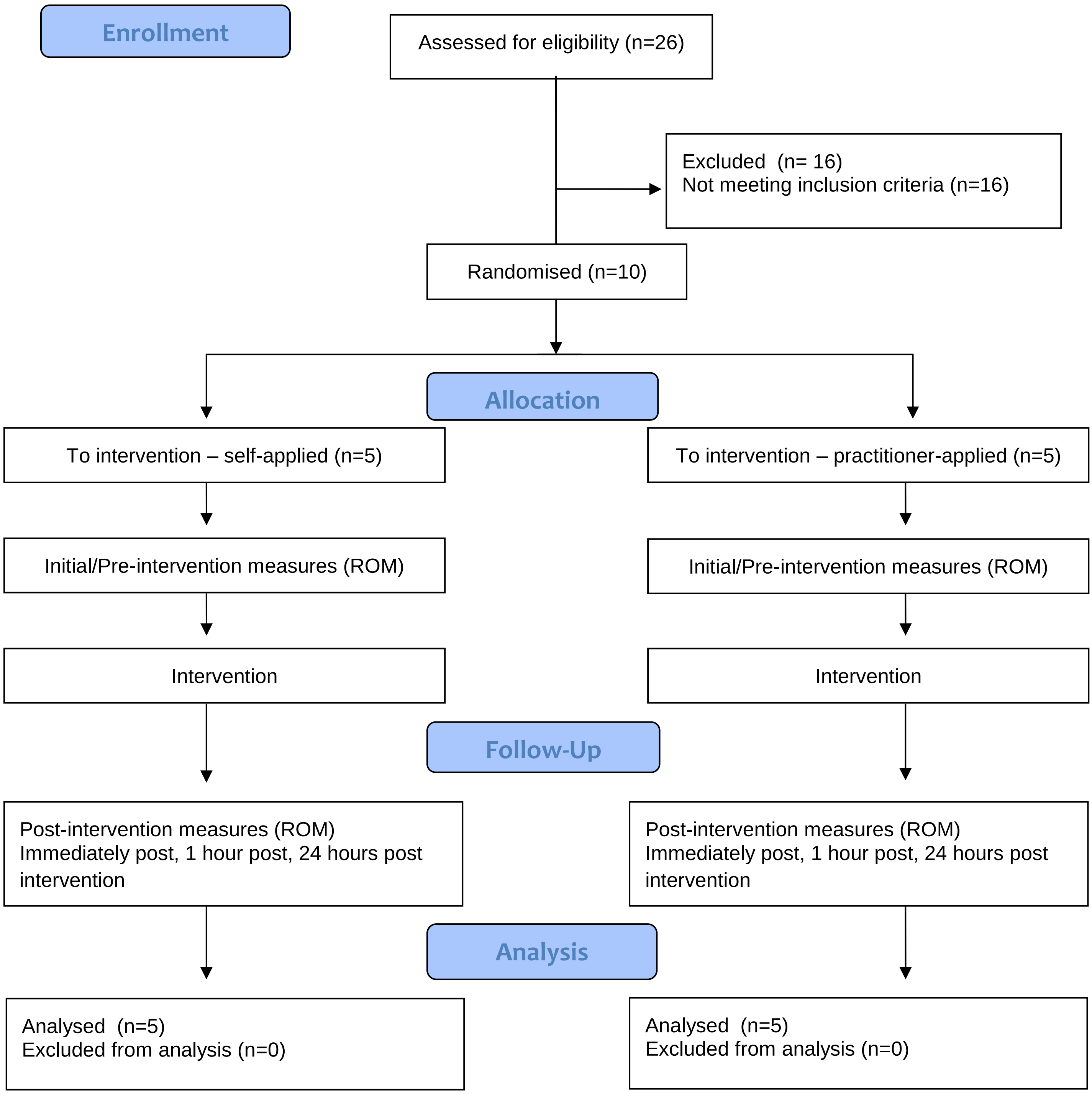

Figure 1. Diagram showing study recruitment flow in CONSORT style (Schulz et al 2010)

2.3 Procedures

2.3.1 Role of research assistants

The practitioner was a final year postgraduate osteopathy student with 2 years clinical training experience who was familiar with myofascial techniques and had received 3 sessions of specific instruction and practice in the technique of interest. The practitioner was responsible for administration of both types of intervention (see 2.4.2 and 2.4.3). A measurement assistant, blinded to group allocation, was responsible for capturing a digital photograph at the point of maximum glenohumeral internal rotation.

2.3.2 Venue and materials

A room with a plain background was used for data collection. Two standard height adjustable plinths were positioned in parallel with a left and right ROM guide as shown in Figure 2. See Figure 3 for patient positioning within the ROM guide. A digital camera mounted on a tripod was positioned to capture digital photographs. The set up was maintained for all data collection sessions.

2.3.3 Participant positioning

Measures were undertaken with participants positioned in supine, with a custom made ROM guide (Figure 2) to maintain 90° of shoulder abduction and 90° of elbow flexion with the forearm in full pronation (Figure 3). An ink mark on the ulnar styloid process and the mid-point of the olecranon process provide reference points for calculation of ROM. Intra-rater reliability of passive shoulder ROM in healthy subjects, positioned in supine and with the shoulder abducted to 90° has been reported to be 'excellent' (ICC[3,1] = 0.88; 95%CI 0.79 to 0.93) (Lunden et al 2010).

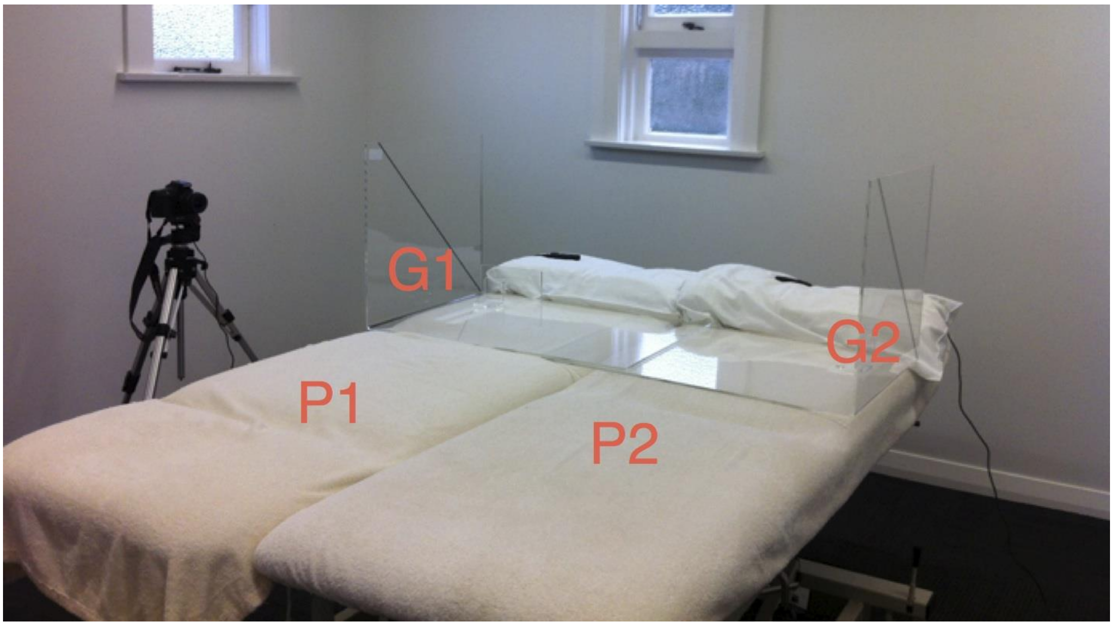

Figure 2. Set up of equipment for data collection sessions
Configuration of plinths (P1 and P2), camera and custom made range of motion guides (G1 and G2). The guides were constructed of 6mm clear acrylic with a 45 degree line of reference on the external surface. For measurement of the right glenohumeral joint, participants were positioned on P1 and G1, with the camera set up as shown in the figure. For measurement of the left glenohumeral joint, participants were positioned on P2 and G2, with the camera on the opposite side. The digital camera was positioned on a tripod 0.95m from the range of motion guide so the focal axis of the lens was perpendicular to the guide to reduce parallax error.

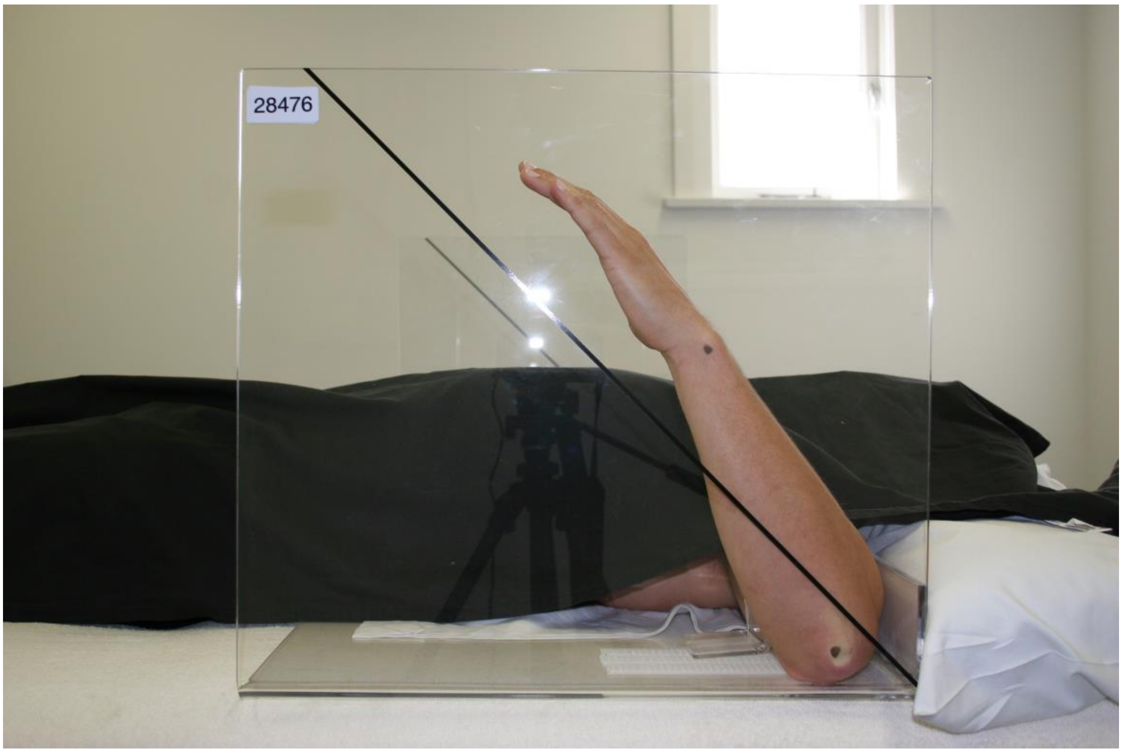

Figure 3. Positioning of participant within range of motion guide
Example of digital image to demonstrate position of participant within the range of motion guide (positioned on P2 with left arm in G2). Note that images used for data analysis were captured with a plain background.

2.3.4 Independent variable (time) in relation to dependent variable (glenohumeral internal rotation ROM)

Active ROM was measured as this is the most clinically relevant variable (Hammer 2007). Measurements of glenohumeral internal rotation were taken at four time points: immediately pre-intervention; immediately post-intervention; 1 hr post-intervention; and 24 hr post-intervention. Participants were asked to refrain from exercising their upper body between measurement sessions as this may have confounded intervention effects. Prior to the 24 hr post-intervention measurement participants were asked to record what exercise, if any, they had performed since the previous measurement. Ten repetitions were performed at each time point and photos captured at maximum glenohumeral internal rotation.

2.4 Intervention

2.4.1 Topographical region for tender site location

The area in which the practitioner was permitted to locate tender sites was within the region illustrated and defined in Figure 4.

Figure 4. Region for tender site location as demonstrated by the shaded area. Bounded superiorly by the inferior border of the clavicle, medially by the lateral aspect of the costal cartilages of ribs 1-4, laterally by the coracoid process of the scapula and the inferolateral edge of pectoralis major, and inferiorly by the 4th rib.

2.4.2 Self-applied technique

The equipment required for the self-applied technique was a firm plastic ball of 71.3mm diameter and a firm plastic (ethylene vinyl acetate) foam block (dimensions H x W x D = 220mm x 150mm x 100mm). The practitioner gave standardised verbal instruction to the participants recruited to the self-applied group and the area they were required to place the ball against their chest was demonstrated. The instructions included two steps as described below, which were repeated 3 times in up to 3 locations across the chest (see also supplementary audiovisual at http://youtu.be/A65I0Mx2LQs):

Stage 1: “Breathe in and use your hands to fix the ball against the front of your chest. Apply firm pressure and movement with the hands so that a stretch can be felt as you exhale.”

Stage 2: “The concept is the same as stage one, however, you should place the ball against your chest and lean against the firm block in a doorway or against the wall. Try introducing forwards and backwards (flexion and extension) movements with the arm to further increase the stretch.”

2.4.3 Practitioner-applied technique

The practitioner-administered technique to the chest was a myofascial compression intended to target the same region as the self-applied technique (see Figure 4). With the participant lying supine, the practitioner located the most palpable, tender site within the clavipectoral fascia. The practitioner flexed their 2nd and 3rd proximal interphalangeal joints such that the middle phalanges were lying flat against the chest to fix against the tender area. The participant was instructed to “take a deep breath ‘into’ the area where the force was applied” and the practitioner maintained tension as the patient exhaled (see also supplementary audiovisual at http://youtu.be/VTdnL5d_rKM). Concurrent with the participant exhalation, the practitioner introduced a passive external rotation movement at the glenohumeral joint, followed by internal rotation.

A minimum of 3 cycles of breathing and passive movement was repeated. Up to 2 additional cycles were permitted if the practitioner had not perceived a change in tissue texture and glenohumeral ROM after the first 3 cycles. The practitioner identified and applied the technique to either 2 or 3 locations in the region of the clavipectoral fascia for each participant. The practitioner was permitted to use clinical judgement in regards to the number of cycles that were performed and locations that were treated, within the guidelines set out previously.

2.5 Data Analysis

2.5.1 Extraction

Glenohumeral internal rotation was measured using digital image analysis software (ImageJ v.1.47.) (Rasband 2012). To maintain researcher blinding, coded file names were processed in randomised order. The mean of 10 repetitions at each time point were used for subsequent data analysis. Still photography and goniometry have been found to have comparable reliability for the measurement of ROM in the shoulder (Hayes et al 2001). Parallax error was determined using a random sample of n=15 digital images and was calculated to be less than 1% (mean±SD = 0.37±0.47°).

Prior to the intervention study the reliability of data extraction; establishment of variation due to multiple trials; intra-session reliability and measurement error were established. Using the procedures described in section 2.3.3, a separate sample of volunteers (n=10) performed 20 repetitions of active glenohumeral internal rotation. To interpret reliability coefficients the qualitative descriptors of Hopkins (2000) were used.

2.5.1.1 Reliability of data extraction

The reliability of extracting the measurements from the digital photographs using ImageJ was established using 20 images randomly selected by an assistant. A reliability test-retest study was performed to estimate measurement errors associated with the researcher's use of the software programme ImageJ. A research assistant randomly sampled 20 images from the pool of 200 images collected. Images were duplicated and assigned coded filenames before being provided to the researcher for analysis on two separate occasions, 3 days apart. The researcher was blinded to their prior results.

A custom spreadsheet was used for the intra class correlation coefficient (ICC) calculation (Hopkins 2011). The ICC for repeated measurement of glenohumeral internal rotation using ImageJ was 'perfect' (ICC = 1.0; 95% CI 1.0 to 1.0).

2.5.1.2 Establishment of variation due to multiple trials

Between repetition variation of glenohumeral internal rotation was established. Ten volunteers performed 20 repetitions of active glenohumeral internal rotation. The data was plotted to observe for a point at which gains in range ceased across the volunteers. Gradual increases in range over consecutive repetitions may be explained by the viscoelastic responses of tissues to cumulative mechanical stress (Bischoff 2006; Ryan et al 2010), thereby introducing potential for measurement artifact. No significant increase in range was observed with a greater number of repetitions. Therefore for the intervention study it was decided that the average of 10 repetitions would be used.

2.5.1.3 Intra-session reliability and measurement error

To evaluate reliability within sessions, glenohumeral internal rotation values were compared between 4 sets of measurements from 10 volunteers. The mean of 5 trials for each session was used for analysis. Reliability coefficients (ICCs) were calculated with 95% confidence intervals. The ICC calculated to express the intra-session reliability of measuring glenohumeral internal rotation was ‘nearly perfect’ (ICC[3,10] = 0.99; 95% CI 0.97 to 0.99). The SEM (standard error of measurement) was calculated to be 0.45°, and the MDC (minimal detectable change) was calculated to be 1.25°.

2.5.2 Statistical Analysis

2.5.2.1 Determination of sample size

In the absence of previously published data reporting changes in glenohumeral ROM following myofascial release, and to maximise sampling efficiency, a group-sequential approach to sampling was used (Hopkins 2006). An initial group of n=10 participants were recruited and analysed with a view to further sampling based on calculated risks of Type I or II statistical errors and the availability of resources. Analysis of n=10 indicated that the risk of Type I error for the main contrasts was less than 5% ($p<0.05$), and in consideration of the preliminary nature of the investigation, and the absence of funding for further data collection, no further sampling was undertaken.

2.5.2.2 Intervention study analysis

The raw data were tabulated in an Excel spreadsheet. Data were analysed with SPSS version 21.0 (IBM SPSS). Variables were explored for assumptions of normality by analysing values for skewness and kurtosis with their standard errors and completing a

Shapiro-Wilk test (Field 2009). Paired samples *t*-test were used to compare ROM for treatment and control limbs for each intervention group at baseline. Independent *t*-tests were used to confirm comparability of treatment limb, and control limb ROM between the practitioner-applied and self-applied groups. A one-way repeated measures ANOVA was used to analyse change within groups across all time points. Plots were constructed to visually represent these data. Cohen's effect sizes (*d*) were calculated for paired samples *t*-tests (Cohen 1988), and effect size *r* for independent *t*-test based on converting *t*-values, as suggested by Field (2009). Hopkins descriptors of magnitudes of effect were used to interpret effect sizes (Hopkins 2002).

3. RESULTS

3.1 Characteristics of participants

Ten participants met the inclusion criteria and were enrolled in the study. All 10 participants who enrolled in the study completed the pre-intervention measurement, intervention, and 3 post-intervention measurements. Participants were all male, mean age of 30.7±5.9 years, and reported a mean of 4.5±1.2 weekly sessions of exercise (defined as activity that raised the heart rate for ≥30 min). Although participants were instructed to refrain from exercising their upper body between measurement sessions, 1 participant recorded exercise including the upper body (strength training) between the post-1 hr and post-24 hr measurements. Four participants recorded lower body exercise (strength training) between the same measurements.

3.2 Statistical assumptions

Z-scores for skewness and kurtosis (of intervention and control groups) pre- to immediately post-intervention, 1 hr post-intervention and 24 hr post-intervention change for ROM were within 95% confidence interval for normal distribution. Similarly, the Shapiro-Wilk test showed no evidence that the distribution varied from normal for changes in ROM. The pre to immediately post and pre to 24 hr post measurements for the control group indicated possible kurtosis, however, did not violate the assumption of normality according to the Shapiro-Wilk test. Levene's test for equality of variances was satisfied in all instances of independent *t*-test use.

3.3 Analysis of Intervention Study

3.3.1 Satisfying assumptions of within limb comparability at baseline

When comparing treatment and control limbs for each intervention group at baseline, paired samples *t*-test showed there was no significant difference observed (Practitioner-applied: mean±SD = -2.23±7.84°, 95%

CI -11.97 to 7.51°, *t*=-0.637, *df* =4, *p*=0.559; Self-applied -2.678±7.023°, 95%CI -11.39 to 6.04°, *t*=-0.852, *df*=4, *p*=0.442).

3.3.2 Satisfying assumptions of between group comparability at baseline

When assessing the comparability of treatment limb, and control limb ROM between the practitioner-applied and self-applied groups at baseline by independent *t*-tests, there were no significant difference in range observed (Treatment limb: mean±SE difference = 3.18±4.69°, 95% CI -7.65 to 13.99°, *t*=0.677, *df*=8, *p*=0.874; Control limb: mean±SE difference = 2.73±6.89°, 95% CI -13.16 to 18.63°, *t*=0.396, *df*=8, *p*=0.708).

3.3.3 Overall effect for treatment limbs regardless of intervention group

Given the treatment limb comparability in each group at baseline, pooled data including both intervention groups could be used for further analysis. The pooled data was analysed prior to comparing the effect of the practitioner-applied intervention with the self-applied intervention. The effect size from pre- to post-intervention was *d*=1.08 ('large'); pre- to 1 hr post-intervention was *d*=0.96 ('large'); and from pre- to 24 hr post-intervention was *d*=0.77 ('moderate-large'). Trivial-small effect sizes were observed between the post-intervention measurements for treatment limbs, indicating that treatment effects were maintained at follow-up measurements. See Table 1.

3.3.4 Overall effect in control limbs regardless of intervention group

Using the results from a one-way repeated measures ANOVA, the effect sizes for the control limb across all time points was shown to be 'trivial' to 'small', indicating that no significant change in ROM occurred. See Table 1.

3.3.5 Comparison of change in ROM for treatment vs control limbs

The pooled data for the treatment and control limbs, regardless of intervention group, are plotted across all time points for comparison (see Figure 5). There was an increase in ROM for the treatment limb between pre-intervention and immediately post-intervention, which was significantly larger than the change observed in the control limb (paired t-test (for treatment limb: difference between pre to immediately post, and control limb: difference between pre to immediately post): mean±SD = -7.64±3.45°, 95% CI -10.11 to -5.17°, t=-7.001, df=9, $p \leq 0.001$). A significantly larger change in ROM was observed for the treatment limb between pre-intervention and 24 hr post-intervention compared with the control limb (paired t-test for (for treatment limb: difference between pre to 24 hr post, and control limb: difference between pre to 24 hr post): mean±SD = -6.94±3.24°, 95% CI -9.25 to -4.63°, t=-6.8, df=9, $p \leq 0.001$).

3.3.6 Overall between group treatment effect

A comparable increase in glenohumeral internal rotation was observed for the practitioner-applied treatment limb group compared to the self-applied treatment limb group (pre to post-intervention: independent t-test, mean±SE difference = 0.68±3.03°, 95% CI -6.3 to 7.66°, t=0.225, df=8, p=0.828, effect size r=0.49; pre to 24 hr post-intervention: independent t-test, mean±SE difference = 3.38±3.3°, 95% CI -4.21 to 10.98°, t=1.027, df=8, p=0.334, effect size r=0.34). See Figure 6 for a plot of ROM for the practitioner-applied and self-applied treatment limb measures across all time points.

3.3.7 Effect size

The results of a one-way repeated measures ANOVA were used to calculate effect sizes for all contrasts. See Table 1 for the effect sizes between all time points for all contrasts.

Table 1. Internal rotation ROM measurements using one-way repeated measures ANOVA and Cohen's *d* effect sizes

	Pre-intervention ROM	Immediately post-intervention ROM	Contrast between Pre- and Immediate-post	1 hr post-intervention ROM	Contrast between Pre- and 1 hr post	24 hr post-intervention ROM	Contrast between Pre- and 24 hr post
Treatment limb[a] (n=10)	16.6 (7.2)	24.3 (10.9)	d=1.08 p<0.001	23.5 (11.2)	d=0.96 p=0.002	22.1 (8.6)	d=0.77 p=0.008
Control limb[b] (n=10)	19.03 (10.4)	19.2 (10.2)	d=0.01 p=0.908	18.8 (10.6)	d=0.02 p=0.856	17.7 (8.9)	d=0.13 p=0.374
Practitioner-applied group: Treatment limb (n=5)	18.2 (6.9)	25.6 (11.3)	d=1.0 p=0.043	25.6 (10.2)	d=0.8 p=0.043	22.03 (9.5)	d=0.6 p=0.225
Self-applied group: Treatment limb (n=5)	14.9 (7.8)	23.1 (11.7)	d=1.1 p=0.043	21.4 (12.9)	d=1.1 p=0.080	22.2 (10.3)	d=0.9 p=0.043
Practitioner-applied group: Control limb (n=5)	20.4 (9.9)	20.5 (8.9)	d<0.01 p=0.893	21.8 (10.3)	d=0.2 p=0.686	18.2 (7.1)	d<0.01 p=0.345
Self-applied group: Control limb (n=5)	17.7 (11.8)	17.9 (12.2)	d<0.01 p=0.893	15.8 (11.1)	d=0.1 p=0.225	17.1 (11.3)	d=0.2 p=0.686

Notes: Results are presented as mean (SD). Units for ROM are degrees°. [a] Treatment limb consists of pooled data (due to comparability at baseline) from practitioner-applied and self-applied groups. [b] Control limb consists of pooled data from practitioner-applied and self-applied groups.

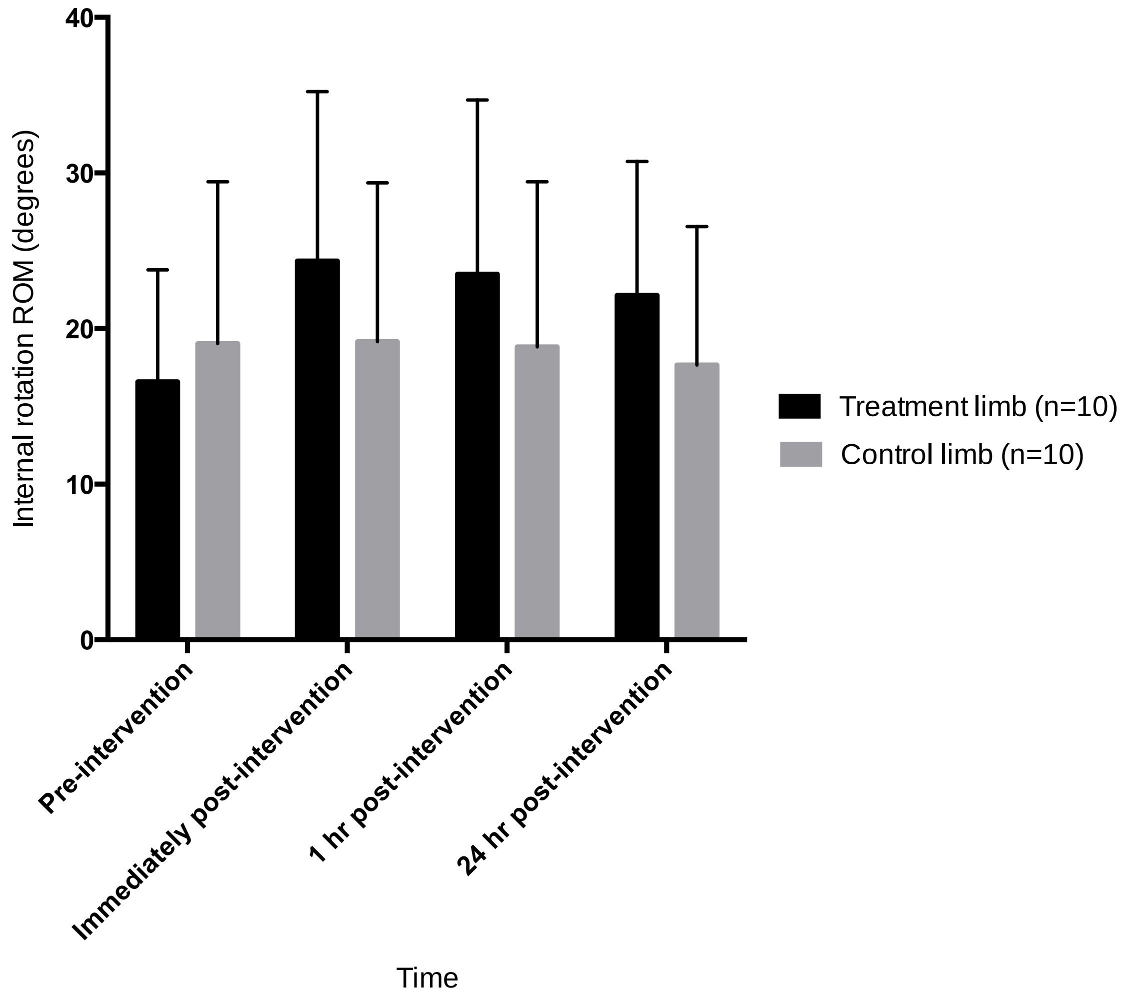

Figure 5. Glenohumeral internal rotation range of motion for treatment and control limbs across all time points

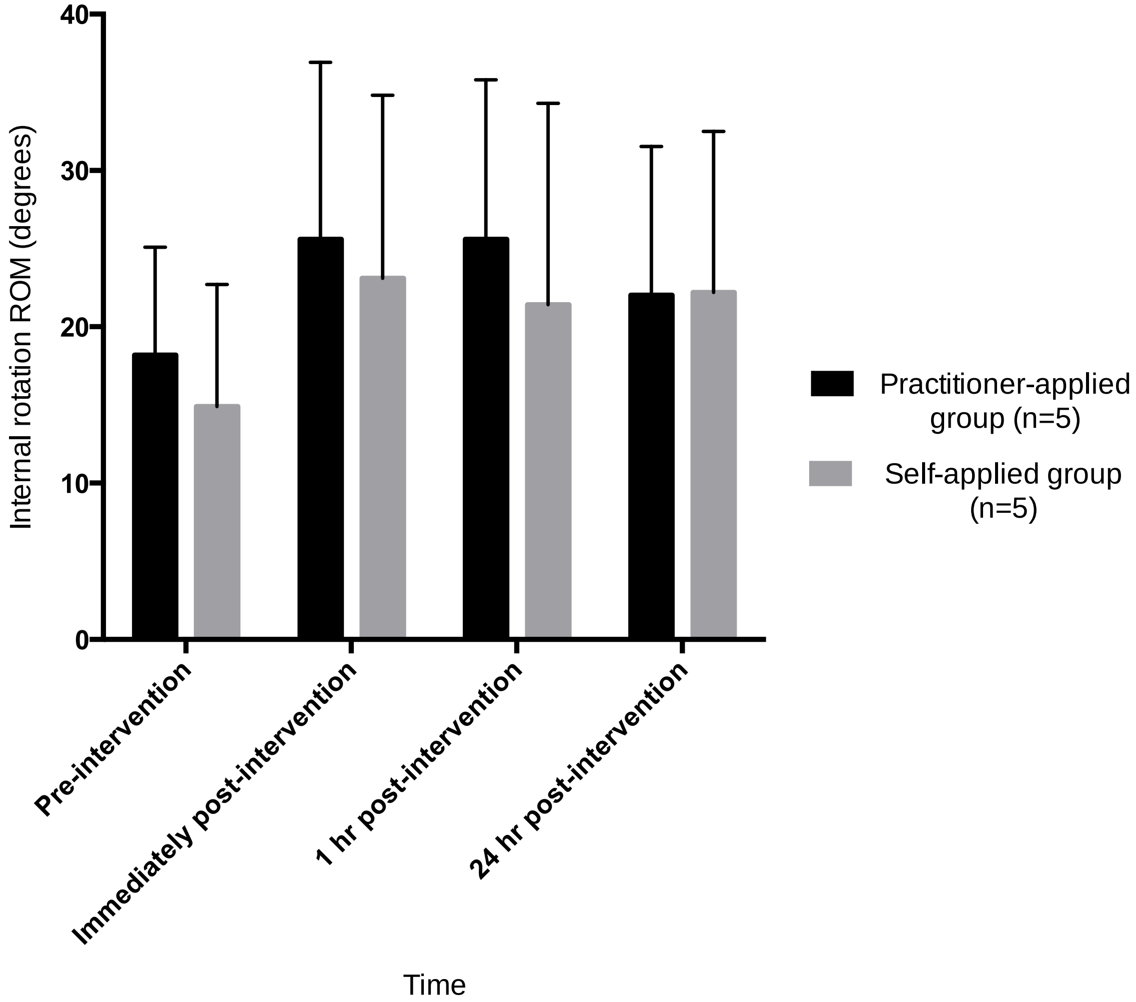

Figure 6. Glenohumeral internal rotation range of motion for practitioner-applied and self-applied treatment limbs across all time points

4. DISCUSSION

The main aim of this study was to investigate the effect of myofascial release to the chest on glenohumeral internal rotation. The study identified a significant, clinically relevant, increase in ROM immediately after application of the technique, which was maintained at 1 hr and 24 hr following the intervention. Comparison of practitioner-applied and self-applied myofascial release techniques indicated similar magnitudes of effect.

Previous studies involving myofascial release

Myofascial release is typically linked to the treatment of myofascial trigger points (de las Peñas et al 2005; Travell & Simons 1992), however, a systematic review of the literature challenges the validity of diagnosis of myofascial trigger points with physical examination (Lucas et al 2009). Due to this diagnostic reliability problem, the trigger point concept was not used in selection of participants, or in the design of the intervention. The inclusion criteria for this study included a combination of participant reported tenderness on palpation (within specified topographical boundaries) and an *a priori* operational definition of reduced ROM. Although previous myofascial release studies have included participants with pain related symptoms (Ajimsha 2011; de las Peñas et al 2005; Hains & Hains 2010; Montanez-Aguilera et al 2010), this study excluded participants with pain. All participants exhibited reduced active ROM – a characteristic that along with other predictors has been associated with increased risk of developing overuse injury and musculoskeletal pain (Cook 2010; Kiesel et al 2013; Lehr 2013; O'Connor et al 2011).

A standardised application of the intervention technique was used in the study to promote consistency between those participants receiving the practitioner-applied intervention and those receiving the self-applied intervention. Practitioner discretion was used to address individual clinical requirements by permitting the practitioner to judge the exact duration of time in treating each tender area and the number of regions across the chest that required treating.

Although the intention of this study was to investigate a specific therapeutic ‘technique’ and not a ‘treatment’ (Patterson 2002; Patterson 2010), a standardised approach to interventions has been effectively demonstrated in other manual therapy studies (Bang & Deyle 2000; Bennell et al 2010). The guidelines for the practitioner permit sufficient standardisation to enable pooling of the data for analysis, while the practitioner discretion was intended to increase the representativeness of the role of the practitioner in real clinical settings (Patterson 2010).

Self-applied myofascial release implications

To date, self-myofascial release (SMR) studies have focused on the application of foam rolling, typically in relation to the lower limb (Healy et al 2014; Okamoto et al 2014). This study presents the first research demonstrating the use of a SMR technique to improve glenohumeral ROM. The main finding of this study is that both practitioner-applied, and self-applied forms of myofascial release to the chest were effective in improving glenohumeral internal rotation. These results are consistent with previous studies of SMR that have demonstrated clinically relevant increases in knee flexion (MacDonald et al 2013) and hamstring flexibility (Sullivan 2013).

As an intervention, SMR could be classified as prescribed therapeutic exercise, and is therefore consistent with an active approach to patient care. It is thought that improving myofascial mobility and ‘resiliency’ could be useful for injury prevention (Boyle 2010; Kjaer et al 2009; Schleip & Muller 2013), although this hypothesis is yet to be comprehensively investigated. There has been increased interest in fascia as a tissue to target in performance oriented strength and conditioning programs, in addition to the current focus on muscular strength, cardiovascular fitness and neuromuscular coordination (Schleip & Muller 2013). One aspect to consider when prescribing therapeutic exercise for patients to perform outside of the supervised clinical setting is that compliance is often poor (Bendermacher et al 2006). Despite evidence supporting the effectiveness of prescribed exercise in combination with manual therapy for pain in regions such as the neck (Masaracchio et al 2013; Miller et al 2010), shoulder (Grant et al 2004; Kromer et al 2009) and low back (Geisser et al 2005; Hayden et al 2005), studies have shown compliance can be as low as 30% (Beinart et al 2013; Schneiders 1998).

Supervised SMR can allow the benefits of self-care to be exploited while minimizing compliance issues. The participants in this study had reduced active ROM in the absence of pain, which is a group that clinical authors have suggested may benefit from more active movement based therapeutic interventions (Cook 2010; Lederman 2009). Measuring active ROM is potentially more clinically useful because it has been demonstrated that changes in passive joint ROM do not automatically transfer into changes in functional movement patterns (Moreside & McGill 2013). The rationale for using an active treatment approach when people have impaired function is that the associated engagement of the motor system leads to neuromuscular adaptation, and potentially a longer lasting effect than passive treatment, where no efferent muscle activity or muscle recruitment occurs (Lederman 2010).

Active treatment approaches have the potential to save time and financial resources (Liebenson 2006), whilst providing the opportunity for greater patient engagement and empowerment (Hibbard 2003; Holmström & Röing 2010). Previous SMR studies investigating the effectiveness of foam rolling have included supervised interventions (Healy et al 2014; MacDonald et al 2013; Okamoto et al 2014), although anecdotally, the prescription of foam rolling is commonly intended for unsupervised settings. The participants in this study received instruction from a practitioner, allowing extrinsic feedback, while also providing the opportunity to engage in active treatment. Athletes and other performance-oriented populations, such as those who have adopted the use of foam rollers, are likely to have high motivation, and therefore compliance, with prescription therapeutic exercise. Future research should investigate unsupervised self-applied interventions to evaluate whether the additional cost of supervision may be justified against the outcomes.

Proposed mechanism of action

The aim of this study was not to explore the mechanism of myofascial release and there is currently only a small body of evidence to support the hypothetical mechanisms of action. Further research is required to improve understanding of the therapeutic mechanisms of myofascial release.

Fascia is a body-wide connective tissue structure with several layers that surrounds structures including muscles, bones, joints and nerves in a three-dimensional web (Langevin 2006; LeMoon 2008; Myers 2008; Schleip 2003b; Stecco 1996). A reduction in the ability of the layers to slide against their underlying structures, such as muscles, is thought to be a significant contributor to myofascial dysfunction (Chaitow 2014; Stecco et al 2011). Hyaluronic acid, a component of collagen and elastin, has been shown to play an important role in viscosity changes of the ground substance (Stecco et al 2011). It is thought that hyaluronic acid, which is found at the junction between fascia and muscle, allows gliding between the two structures (McCombe et al 2001). Mechanical stimulation (such as myofascial release) has been shown to increase production of hyaluronic acid (Roman et al 2013), which may decrease the resistance of fascia and muscle layers to glide over one another by reducing ground substance viscosity. However, these claims currently have little supporting experimental evidence and only recently have technological advancements allowed for preliminary investigations into tissue excursion (Guimberteau et al 2005; Guimberteau et al 2010; Yoshi et al 2009).

The biochemical effects of mechanical stress on the cells within fascia appear to occur within minutes (Langevin et al 2011), however, the tissue has also been demonstrated to undergo changes with longstanding mechanical stress. It has been demonstrated that fascia is remodeled in response to the physiological demands placed on it (Kjaer 2009). Changes in collagen can eventually result in the formation of cross-links between fibres (Fratzl 2008), which is thought to alter the viscoelastic properties of fascia and contribute to myofascial dysfunction. A reduction in the strength of cross-links between collagen fibers and therefore adhesions leads to an improved ability of fascial layers to slide over one another (Martínez Rodríguez & Galán del Rio 2013).

It is important to recognise that, while the initial mechanical models to support the mechanism of myofascial release are biologically plausible, flaws exist in this concept. For example, research suggests that the force applied by manual therapists may not be adequate enough to cause significant collagen deformation (Martínez Rodríguez & Galán del Rio, 2013). However, alternative models have been proposed, including neurophysiological explanations. The discovery of the presence of mechanoreceptors in fascia (Stecco et al., 2007) implies that myofascial release could stimulate these receptors, leading to altered afferent inputs to the central nervous system and a response that relaxes contractile fibres. Although much investigation is needed to further support the neurophysiological model, it is a concept that should be considered when using myofascial release.

<u>Internal validity, study limitations and generalisability</u>

In this randomised controlled experiment internal validity was improved by blinding the researcher until the point of data analysis. Blinding the measurement assistant to the participant and intervention group further minimised potential for knowledge of group allocation to introduce bias. In this preliminary study several limitations have been identified, including a small sample size, which limits the ability of the results to be generalised beyond the sample. Future studies should include a larger sample size and include subgroups of both males and females to allow comparison between sexes. Healthy, recreationally active males were recruited to promote sample homogeneity a necessary characteristic of single technique studies (Patterson 2010). Research has shown variations in glenohumeral joint laxity and stiffness between genders (Borsa et al 2000). In addition to this, studies have shown that the sex hormones estrogen and relaxin can impact on the elasticity of connective tissue and may account for the differences in muscle and ligament composition between males and females (Hewett et al 2007; Negishi et al 2005; Park et al 2009).

To avoid potential problems of inter-practitioner standardisation within this study, one practitioner was used. Delivery of the intervention techniques did not require the practitioner to possess advanced clinical skills, and with minimal instruction, would be reproducible by any trained manual therapy practitioner.

In undertaking multiple repetitions of shoulder ROM, increases in range may arise as a function of the repeated movements. Pilot work performed as part of this study investigated the natural variation of glenohumeral internal rotation over 20 consecutive repetitions and found there to be no significant increase. In addition to the controlled design (control limb) results of the pilot study provide greater confidence that the improvements in range seen in the main study are due to the intervention.

Clinical implications and future research

When planning future research it is relevant to note that 26 potential participants were screened for eligibility to yield 10 participants – a ratio of 2.6:1. To achieve a more generalizable sample, for example 100 participants, it would be necessary to screen approximately 260 people, which may introduce resourcing issues.

The present study was conducted in a controlled laboratory environment therefore the results should be applied cautiously in clinical settings. The change in ROM was observed following one application of a technique to a single body area. Typical manual therapy approaches to improving shoulder function include the application of multiple techniques over multiple sites, potentially including the glenohumeral joint capsule (Vermeulen et al 2000), the rotator cuff (Bang et al 2000; Hammer 2007), cervical (McClatchie et al 2009; Mintken et al 2010) and thoracic spine (Edmondston et al 2012; Lewis et al 2005; Mintken et al 2010; Sueki & Chaconcas 2011), and scapulothoracic mobility (Lewis et al 2005). This study improves theoretical understanding of the efficacy of myofascial release and provides a rationale for future studies to integrate the techniques used in this study into a more sophisticated treatment plan, to be researched in a clinical outcomes study.

5. CONCLUSION

This randomised controlled experiment found that myofascial release to the chest increases glenohumeral internal rotation. Results show that the effect on ROM is comparable when myofascial release is applied by a practitioner or with self-application under practitioner supervision. This study also demonstrated that increased ROM is maintained in the 24 hours following application of the technique. Given the preliminary nature of this study, it is recommended that a clinical outcomes study with a larger sample size be conducted to improve generalisability.

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Section 3: Appendices

Appendix A: Participant Information Sheet

Unitec NEW ZEALAND Te Whare Wānanga o Wairaka

Information sheet for participants (practitioner-applied technique)

The effect of myofascial compression to the chest wall on shoulder internal rotation

Thanks for your interest in participating in this research. This sheet provides more information about the research but please feel free to discuss any other questions you may have.

You are invited to take part in a research project investigating the effect of a technique applied to the front of the chest (pec muscle region) on shoulder range of motion (in this case we will be measuring internal rotation)

Who is undertaking this research?
This research is being undertaken by Mandy Smythe (Master of Osteopathy student) under the supervision of Rob Moran (Department of Osteopathy, Unitec).

Where will the research take place?
Clinic 41 – the Unitec Osteopathic Clinic (Carrington Rd, Mt Albert).

Why are you doing this research?
This research project is investigating the effect of myofascial compression to the chest on shoulder motion.

Myofascial compression is a technique used by physical therapists to produce a strong stretch in tissues that have become dysfunctional and are causing pain or restriction of motion. Practitioners use their hand to firmly compress the soft-tissue (muscle) to an area just below the collar bone as they perform this technique.

What will happen in this research?
Should you agree to be part of this research, you will be required to attend an initial session (one and a half hours duration) and a session one day after the initial session (15 min duration).

In the initial session measurements of shoulder mobility will be taken and the technique will be performed. Immediately after the technique is completed, your shoulder mobility will be measured again. You will then be required to wait one hour, at which time a further measurement will be taken. If you wish to leave the clinic and return after one hour you will be able to do so.

Once I start can I withdraw from the study later?

If you wish to withdraw from the study, you may do so for any reason up until the end of the data collection stage. All personal information you provide will be treated as confidential and no material that could personally identify you will be used in any reports on this project.

Who can I contact with any further questions?

If you have any further questions about this research please feel free to contact one of us:

Principal Investigator:
Mandy Smythe
Tel: 021 025 90676
Email: asmythe@live.com

Research Supervisor:
Robert Moran
Tel: 021 073 9984 or 815 4321 x8197
Email: rmoran@unitec.ac.nz

Unitec
NEW ZEALAND
Te Whare Wānanga o Wairaka

Information sheet for participants (self-applied technique)

The effect of myofascial compression to the chest wall on shoulder internal rotation

Thanks for your interest in participating in this research. This sheet provides more information about the research but please feel free to discuss any other questions you may have.

You are invited to take part in a research project investigating the effect of a technique applied to the front of the chest (pec muscle region) on shoulder range of motion (in this case we will be measuring internal rotation)

Who is undertaking this research?
This research is being undertaken by Mandy Smythe (Master of Osteopathy student) under the supervision of Rob Moran (Department of Osteopathy, Unitec).

Where will the research take place?
Clinic 41 – the Unitec Osteopathic Clinic (Carrington Rd, Mt Albert).

Why are you doing this research?
This research project is investigating the effect of myofascial compression to the chest on shoulder motion.

Myofascial compression is a technique used by physical therapists to produce a strong stretch in tissues that have become dysfunctional and are causing pain or restriction of motion. Practitioners use their hand to firmly compress the soft-tissue (muscle) to an area just below the collar bone as they perform this technique. Self-application of the technique is also possible. As a participant you will be taught how to perform the technique and supervised while you complete it.

What will happen in this research?
Should you agree to be part of this research, you will be required to attend an initial session (one and a half hours duration) and a session one day after the initial session (15 min duration).

In the initial session measurements of shoulder mobility will be taken and you will be taught how to apply the technique. Immediately after the technique is completed, your shoulder mobility will be measured again. You will then be required to wait one hour, at which time a further measurement will be taken. If you wish to leave the clinic and return after one hour you will be able to do so.

Once I start can I withdraw from the study later?

If you wish to withdraw from the study, you may do so for any reason up until the end of the data collection stage. All personal information you provide will be treated as confidential and no material that could personally identify you will be used in any reports on this project.

Who can I contact with any further questions?

If you have any further questions about this research please feel free to contact one of us:

Principal Investigator:
Mandy Smythe
Tel: 021 025 90676
Email: asmythe@live.com

Research Supervisor:
Robert Moran
Tel: 021 073 9984 or 815 4321 x8197
Email: rmoran@unitec.ac.nz

Appendix B: Consent Form

Participant consent form

The effect of myofascial compression to the chest wall on shoulder internal rotation

Name of Participant: ____

I have seen and read the information sheet for participants taking part in the project titled "The effect of myofascial compression to the anterior chest wall on shoulder internal rotation" and have had the opportunity to discuss the project with Mandy Smythe or Rob Moran.

I understand that I am volunteering to partake in this study of my own volition, and I may withdraw at any time up to the completion of the data collection aspect of the research project.

I understand that my participation in this project is confidential and that no material that could personally identify me will be used in any reports on this project.

I understand that I can see the finished research document.

I have had enough time to consider whether I want to take part and acknowledge that any data collected during the study will be stored securely so that only the researchers may access them.

The principal researcher for this project is Mandy Smythe, principal supervisor is Rob Moran.
Contact details: Mandy Smythe
Email: asmythe@live.com
Phone: 021 02590676

Participant Signature: _________________________ Date:________________

The participant should retain a copy of this consent form

UREC REGISTRATION NUMBER: 2012-1099
This study has been approved by the Unitec Research Ethics Committee from 21.02.13 to 21.02.14

Appendix C: Ethics Approval Letter

Mandy Smythe
18 Connolly Ave
Three Kings
Auckland

Unitec
Institute of Technology

21.2.13

Dear Mandy,

Your file number for this application: **2012-1099**
Title: **The effect of myofascial compression to the anterior chest wall on glenohumeral internal rotation.**

Your application for ethics approval has been reviewed by the Unitec Research Ethics Committee (UREC) and has been approved for the following period:

Start date: 21.2.13
Finish date: 21.2.14

Please note that:

1. **The above dates must be referred to on the information AND consent forms given to all participants.**

2. **You must inform UREC, in advance, of any ethically-relevant deviation in the project. This may require additional approval.**

3. **Organisational consent/s must be cited and approved by your primary reader prior to any organisations or corporations participating in your research. You may only conduct research with organisations for which you have consent.**

You may now commence your research according to the protocols approved by UREC. We wish you every success with your project.

Yours sincerely,

PP-

Gillian Whalley
Deputy Chair, UREC

Cc: Rob Moran
Cynthia Almeida

study@unitec.ac.nz
Tel +64 9 849 4180
Fax +64 9 815 2901
www.unitec.ac.nz

Postal address
Private Bag 92025
Victoria St West
Auckland 1142
New Zealand

Mt Albert campus
139 Carrington Rd
Mt Albert
Auckland 1025
New Zealand

Newmarket campus
277 Broadway
Newmarket
Auckland 1023
New Zealand

Northern campus
10 Rothwell Ave
North Harbour
Auckland 0632
New Zealand

Waitakere campus
5-7 Ratanui St
Henderson
Auckland 0612
New Zealand

Appendix D: Journal of Bodywork and Movement Therapies: Instructions for Authors

Journal of Bodywork and Movement Therapies

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•title of the article

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•name, address, telephone and fax numbers of the author responsible for correspondence and to whom requests for reprints should be sent.

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Avoid the use of first person ('I' statements) and second person ('you' statements). Third person, objective reporting is appropriate. In the case of reporting an opinion statement or one that cannot be referenced, the rare use of 'In the author's opinion?' or 'In the author's experience?.' might be appropriate. If in doubt, ask the editor or associate editor for assistance.

Acronyms used within the text are spelled out at the first location of usage and used as the acronym thereafter. For example, 'The location of a central trigger point (CTrP) is central to a taut fiber. The CTrP is palpated by......'

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