# Effects of a short-term osteopathic intervention on vertical jump and reach height in female recreational overhead athletes: A cross-over design.

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A research thesis submitted in partial fulfilment of the requirements for the degree of Master of Osteopathy, Unitec Institute of Technology, 2016

## Declaration

**Name of candidate:** Thalia Calantha Green

This thesis entitled "Effects of a short term osteopathic intervention on the vertical jump and reach height in female recreational overhead athletes: A cross over design." is submitted in partial fulfilment for the requirements for Unitec degree of Master of Osteopathy.

### Candidates Declaration

I confirm that:

- This thesis 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 Number: 2014-1093

Candidate Signature: ..................................................... Date: 29/3/17

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## Abbreviations

| | |
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| VGRF | Vertical Ground Reaction Force |
| VGRI | Vertical Ground Reaction Impulse |
| TBCM | Total Body Centre of Mass |
| MVC | Maximum Voluntary Contraction |
| GIRD | Glenohumeral Internal Rotation Deficiency |
| ROM | Range Of Motion |
| TRM | Total Rotational Motion |
| MET | Muscle Energy Technique |
| ST | Soft Tissue |
| SFMPQ | Short-form McGill Pain Questionnaire |
| VAS | Visual Analogue Scale |
| PPI | Present Pain Index |
| HVLA | High Velocity Low Amplitude |
| SPADI | Shoulder Pain and Disability Index |
| TENS | Transcutaneous Electrical Nerve Stimulation |

## Introduction to Thesis

Athletes competing in overhead sports such as basketball, netball and volleyball at a professional level require exceptional vertical jump performance (Bobbert & Van Soest, 1994). An increased ability to jump high improves the athlete's ability to reach up and intercept or spike the ball. Numerous studies have been conducted to investigate improving vertical jump height (Bobbert & Van Soest, 1994; Kraska et al., 2009; Maffiuletti, Dugnani, Folz, Pierno, & Mauro, 2002; Newton, Kraemer, & Häkkinen, 1999; Saez de Villarreal, Gonzalez, & Mikel, 2014). The most common approach is resistance training of the lower extremities, which increases maximal muscular force and explosive power in the legs, thereby increasing an individual's ability to jump (Sankarmani, Sheriff, Rajeev, & Alagesan). An area that has not been as greatly researched is the upper body. Various studies report limitations in shoulder mobility, particularly in athletes who frequently perform overhead arm movements (Downar & Sauers, 2005; Lees, Vanrenterghem, & De Clercq, 2004). Research has also demonstrated that the inclusion of arm swings during a vertical jump can create a significant increase in the vertical ground reaction force (GRF) produced and the overall jump height (Blache & Monteil, 2013; Hara, Shibayama, & Fukashiro, 2001; Harman, Rosenstein, Frykman, & Rosenstein, 1989; Shetty & Etnyre, 1989). Despite this, there is limited research to show that by increasing the mobility of the shoulder and thoracic spine, an athlete will be able to reach higher. There is also a lack of research examining female athletes. Testing both genders is important due to the differences between the two such as ligament laxity (Chung & Wang, 2009), strength (Frontera, Hughes, Lutz, & Evans, 1991) and anatomy of the shoulder complex (Merrill, Guzman, & Miller, 2009). Females have a tendency to have a greater ROM and flexibility through the shoulder than males (Chung & Wang, 2009; Doriot & Wang, 2006), therefore may respond differently to treatment to improve the range of motion (ROM) of this region.

Decreased shoulder ROM is often addressed by manual therapists, including osteopaths, by applying techniques such as Soft Tissue (ST) massage and Muscle Energy Technique (MET) to the musculature of the shoulder and surrounding areas (Moore, Laudner, McLoda, & Shaffer, 2011; Van den Dolder & Roberts, 2003). High Velocity Low Amplitude (HVLA) thrusts of the thoracic spine have also appeared to positively reduce shoulder pain and disability, therefore are also commonly employed to help improve shoulder ROM (Boyles et al., 2009). The use of these three techniques and their influence on joint mobility (including shoulder mobility) has been separately examined in a number of studies (Boyles et al., 2009; Moore et al., 2011; Van den Dolder & Roberts, 2003), however, there is limited literature that incorporates all three into a complete treatment. Therefore, the aim of this thesis was to investigate the effects of such an osteopathic treatment on shoulder and thoracic ROM in female athletes, with the aim of increasing the overhead reach portion of a vertical jump, using a jump and reach test.

This thesis is arranged in three sections. Section One is a literature review which examines previous research surrounding the improvement of jumping ability and the mechanics of jumping, and the influences of osteopathic techniques including ST, MET and HVLA. Section Two is a manuscript, formatted for submission to the Journal of Strength and Conditioning Research, that reports on a study investigating the previously explained aims. Section Three contains Appendices to the thesis.

# Section 1

# Literature Review

## Introduction

The ability to jump high is a tremendous asset for athletes to possess in various sporting activities, therefore the methods of improving it have already been comprehensively reviewed throughout the literature (Bobbert, 1990; Gehri, Ricard, Kleiner, & Kirkendall, 1998; Luebbers et al., 2003; Maffiuletti et al., 2002; Saez de Villarreal, Kraemer, & Izquierdo, 2009; Sheppard et al., 2011). Various strategies for enhancing vertical jump have been investigated, including strengthening of the lower extremities through differing jumping styles (Bobbert, 1990; Gehri et al., 1998; Luebbers et al., 2003; Sheppard et al., 2011). Though ample research has focused on the lower body, only a few studies have investigated the influence of an arm swing on vertical jump (Blache & Monteil, 2013; Hara et al., 2001; Harman et al., 1989; Shetty & Etnyre, 1989). The importance of adequate shoulder mobility in the overhead reach motion during sports is an area that has been largely overlooked, despite there being sufficient research to indicate limited shoulder range of motion (ROM) being a common problem within overhead sports players due to repetitive motions undertaken (Forthomme, Croisier, Ciccarone, Crielaard, & Cloes, 2005; Wang & Cochrane, 2001; Wilk et al., 2011). Poor posture (Greenfield et al., 1995) and structural differences between genders (Chung & Wang, 2009) also have influences on shoulder ROM. The role of osteopathy, specifically techniques such as soft tissue (ST) massage, muscle energy technique (MET) and high velocity low amplitude (HVLA) thrusts, have been fairly well researched (Fryer, 2000; Haik et al., 2014; Moore et al., 2011; Shadmehr, Hadian, Naiemi, & Jalaie, 2009; Strunce, Walker, Boyles, & Young, 2009; Van den Dolder & Roberts, 2003; Wright & Sluka, 2001) and provides evidence to support the use of these techniques in the improvement of shoulder and thoracic spine ROM.

The literature review was performed using online databases including Google Scholar, Pubmed and EBSCO host. The keywords used included: shoulder, mobility, jump reach, jump height, active stretching, posture, gender, osteopathy, manual therapy, soft tissue, massage, muscle energy technique, manipulation and HVLA.

## Vertical Jumping

*Jump Reach*

Jump height and jump reach are important aspects of a number of sports including basketball, netball and volleyball. They are used when dunking the basketball, during interceptions or spiking the volleyball (Bobbert, 1990). For this reason, improving jump height has been an area that has been extensively researched in order to find a quick, effective method applicable during training sessions (Bobbert, 1990). Plyometric training has been an area of great interest to a number of researchers following success in the practical applications when utilised by coaches and their athletes (Bobbert, 1990; Gehri et al., 1998; Luebbers et al., 2003; Maffiuletti et al., 2002; Saez de Villarreal et al., 2009; Sheppard et al., 2011). Plyometric training traditionally involves various jumping and hopping exercises. The targeted muscles contract eccentrically, creating a stretch reflex which is thought to produce a greater concentric contraction in the push off phase of jumping (Luebbers et al., 2003). Gehri et al. (1998) and Bobbert (1990) both compared drop jump training to countermovement jumping on their abilities to influence overall jump height. During the drop jump the participant jumps from a raised platform onto the ground, then immediately pushes off from the ground into a vertical jump. It is thought that the individual will have an increase in elastic energy stored following the initial landing that can be utilised during the push off phase of the vertical jump (Bobbert, 1990). A countermovement jump is a better representation of how an athlete would perform during a sports game. The participant begins in a standing upright position, bends the knees to lower the centre of mass before extending upright and pushing off into a vertical jump (Bobbert, 1990). Both Gehri et al. (1998) and Bobbert (1990) found that no one training programme surpassed the other in terms of improving jump height, but that any form of plyometric training resulted in significant improvements. Other researchers have investigated the duration of plyometric training programmes and the amount of post-training recovery in the response (Saez de Villarreal et al., 2014). Luebbers et al. (2003) used drop jumps alongside vertical, tuck, broad and single leg jumps in their study, comparing the effects of a 4-week and 7-week plyometric training programme. During the immediate follow up, both groups showed a significant decrease in jump height, more so in the 4-week group. They decreased from an average jump height of 67.8±7.9 cm (mean±SD) to 65.4±7.8 cm, while the 7-

week group reduced from 64.6±6.2 cm to 64.4±8.8 cm. The participants then underwent a 4-week recovery period before testing resumed, and interestingly, significant improvements were noticed following this time. The 4-week group obtained an average of 69.7±7.6 cm, a 1.9 cm increase from the pre-testing measurements, and the 7-week group gained 2.6 cm, resulting in an average jump height of 67.2±7.6 cm.

Assisted countermovement jump training is another form of intervention used by Sheppard et al. (2011) in order to attempt to increase jump height. Participants underwent a programme consisting of 25 – 35 jumps, 3 days a week, for 5 weeks. The assistance was a band around the bottom of the feet that was stretched above their head and tightened to reduce their mass on a force plate by 10kg. This group was compared to a control group who performed the same number of countermovement jumps without assistance. Following the 5-week intervention period, the participants underwent a 3-week recovery period during which no jumping was performed. Sheppard et al. (2011) found the results of this trial to differ from the others reviewed above (Bobbert, 1990; Gehri et al., 1998; Luebbers et al., 2003). They found no significant improvement compared to carrying out non-assisted countermovement jumps over the same 5-week period of time, with an average increase of only 1±1.3 cm. On the other hand, assisted countermovement jump training showed significant improvements of 2.7±0.7 cm. The lack of improvement in the non-assisted jumps seen by Sheppard et al. (2011) may be due to the participants being elite volleyball players, therefore their bodies may already be trained to effectively perform countermovement jumps. Luebbers et al. (2003) and Gehri et al. (1998) recruited physically active individuals, however none that were currently involved in jumping sports, therefore they were not likely to be pre-conditioned to countermovement jumping and might therefore have more room for improvement. Although the non-assisted jump training results displayed by Sheppard et al. (2011) were not statistically significant, there was still an overall increase in jump height of 0.5cm, suggesting that simple countermovement jump training could still be an effective form of training to improve jump height. However the assisted training appears to be more beneficial.

*Arm Swing*

Training of the lower body is not the only way in which height can be influenced. Four studies have employed force plate and cinematographic data analysis to investigating the effect of swinging the arms on jumping by calculating differences with and without arm swing in vertical GRF, peak torques, and centre of mass (Blache & Monteil, 2013; Hara et al., 2001; Harman et al., 1989; Shetty & Etnyre, 1989). They found swinging the arms above the head during a vertical jump increases the maximum GRF by 6 – 10% (Harman et al., 1989; Shetty & Etnyre, 1989) and the overall jump height by 6 – 9 cm (Blache & Monteil, 2013; Hara et al., 2001). All four studies randomised the order of arm swing conditions and allowed rests of up to 3 minutes between jumps. Although the jumping styles were similar between studies, Blache & Monteil (2013) only looked at the effects of a squat jump with and without arms, Harman et al. (1989) chose to utilise the countermovement jump style. Hara et al. (2001) used both styles and compared the differences. There was no specification as to which style was selected by Shetty & Etnyre (1989). They allowed the participant to employ their desired jumping style, however they ensured each jump performed remained consistent.

Harman et al. (1989) found that in a sample of physically active males, employing the arms during a jump increased the net vertical ground reaction impulse (VGRI) by 10%, as well as an average increase of 6 cm vertical height of the total body centre of mass (TBCM) following take off. An even greater increase in jump height was observed by Blache & Monteil (2013) and Hara et al. (2001), who both revealed an average increase of 9 cm in healthy males. A change in jump height was not examined by Shetty & Etnyre (1989), however they did obtain sufficient evidence to support their original hypothesis that power (by 14%), work output (by 15%) and VGRI (by 6%) are increased in male individuals when jumping with the inclusion of an arm swing compared to without.

Several authors have extended this research to determine the mechanism of arm swing improvements in vertical jump (Feltner, Fraschetti, & Crisp, 1999; Harman et al., 1989; Lees, Vanrenterghem, & Clercq, 2004; Payne, Slater, & Telford, 1968). Payne et al. (1968) initially proposed it was due to a downward force being exerted through the body in response to the upward force of the acceleration of the arms. This downward force resulted in an increase in GRF, an increase in peak vertical velocity, and in turn, an increase in jump height. However, this is a relatively simplistic explanation. It wasn't until Feltner et al. (1999) examined the kinetics and kinematics of the hips, knees, ankles and trunk during the different stages of countermovement jumping, both with and without arm swing, that a more detailed theoretical analysis was published. They observed that as the individual initiated the extension phase of the jump, a counterclockwise rotation movement of the trunk took place. As the participant began to raise their arms upwards, a reciprocal downwards force was applied to the trunk, similar to that first described by Payne et al. (1968). This downward force applied to the trunk created a clockwise rotation movement which countered the counterclockwise movement, thus slowing the rate in which it occurred (Feltner et al., 1999). This change in trunk rotation caused a decrease in the rate of hip extension, a decreased rate of concentric contractions of the hip extensors, and an overall increase in hip extensor torque. The reduction in extension velocity allowed for a greater increase in torque development in the primary hip extensor musculature. As the arms reach further above the head, their vertical acceleration decreases, decreasing the clockwise rotational movement on the trunk. A decrease in clockwise trunk rotation allows for the resumption of a counterclockwise rotational force through the trunk and hips and significantly greater angular velocity of the hip. Alongside this change, an increased rapid concentric contraction of the hip extensor musculature and a greater increase in hip torque occurs. As a result of this process, a larger downward peak vertical force (impulse) was observed just prior to take off period in the arm swing jumps (Feltner et al., 1999). This conclusion supports the inclusion of an arm swing in an increase in overall jump height.

Another theory was previously proposed by Harman et al. (1989). Their idea was that as the arms reached their vertical velocity, the momentum slowed and transferred the remaining energy to the rest of the body and "pulled" the trunk upwards. Again, this theory was not elaborated on until Lees et al. (2004) examined the mechanisms in further detail. The use of the arms changes the position of the trunk by allowing it to be positioned further forwards. This puts the gluteal muscles in a lengthened state, causing them to contract eccentrically, thus producing greater force (Brughelli &

Cronin, 2007). Additionally, the trunk extends earlier and at a faster rate, therefore generating more power and increasing the torque in the lower extremity. The acceleration of the arms as they are raised also generates energy through the shoulder and the elbow. As the arms pass horizontal, they begin to decelerate and their energy declines. Although it is not known, it is believed the energy does not dissipate at this point, but is transferred to the tendons and muscles in the lower body. A net joint force from the arms produces an upward force, or "pull", on the trunk, elevating the centre of mass. Knee and ankle joint angular velocities also increase, and combined with the already amplified torque, cause an increase in power output (Lees et al., 2004).

## Stretching

Muscle strengthening is not the only aspect of training that is employed by athletes and their coaches to enhance performance. For years, static stretching, before performing any form of strenuous exercise, has been considered a key component of an athlete's warm up, undertaken in order to prevent injury and increase performance (Behm & Chaouachi, 2011). Static stretching involves taking a limb to its end of range of movement and holding it for any given length of time. It is believed that this decreases the stiffness of the musculotendinous unit, thus increasing the overall length of the muscle (Behm & Chaouachi, 2011). However, over the last 20 years, more research has emerged claiming that static stretching may decrease force output of the involved musculature when performed prior to activity (Fowles, Sale, & MacDougall, 2000; Marek et al., 2005; Power, Behm, Cahill, Carroll, & Young, 2004).

Various research papers have been published looking at the different effects of stretching, such as on muscle length and joint ROM (Laudner, Sipes, & Wilson, 2008; McClure et al., 2007), injury prevention (Pope, Herbert, & Kirwan, 1998; R. P. Pope, Herbert, Kirwan, & Graham, 2000) and muscle force (Behm et al., 2006; Fowles et al., 2000; Manoel, Harris-Love, Danoff, & Miller, 2008; Marek et al., 2005; Power et al., 2004). McClure et al. (2007) and Laudner, Sipes, and Wilson (2008) both examined the effects of the sleeper stretch on overall shoulder ROM in comparison to a control group, who were instructed to avoid stretching of either limb. A sleeper stretch involves internal rotation of the shoulder and is undertaken with the participant lying on the side with the humerus resting on the table and the forearm bent at 90°, pointing towards the ceiling. The shoulder is then internally rotated in order to create a stretch through the posterior musculature (McClure et al., 2007). McClure et al. (2007) also included a group who were directed to perform an across the body stretch where the shoulder is taken into full adduction. Both intervention groups were compared to the opposite limb, as well as to the control group. The results of these two studies demonstrate a significant increase in the mean internal rotation ROM of the affected shoulder of 12.4±11.9° (McClure et al., 2007) and 3.1° (Laudner et al., 2008). Though not in relation to the shoulder, Bandy, Irion, and Briggler (1997) noticed a significant improvement of between 10 – 11.5° in hamstring length and knee extension flexibility of 93 subjects following a 6-week stretching protocol of the hamstrings. They tested 5 different groups, each who performed the stretch for differing amounts of time, and compared the results to a control group who did no stretching over that time. While there was a large improvement difference of around 10º between those who carried out the stretching compared to those who did not, Bandy et al. (1997) reached the conclusion that stretching for longer than 30 seconds at one time was no more beneficial than holding the stretch for shorter durations. Although the results of these three studies are positive, the post-intervention testing was performed immediately following both interventions, with no follow up testing. Therefore, we are unable to determine the lasting effects of either of the stretches. Willy, Kyle, Moore, and Chleboun (2001) completed a study which followed up on their twenty-four participants for 4-weeks following a 6-week bout of static stretching of the hamstrings. While there was a significant increase in muscle flexibility during and directly after the 6-week stretching programme, there was no continuation of this after 4-weeks of no stretching. In order to maintain flexibility, Willy et al. (2001) suggest that performers continue their 30-second hamstring stretches, twice a day, 5 times a week. These studies show that stretching is beneficial for improving ROM in the direction of the stretch. To the authors knowledge, no studies have shown increases in shoulder abduction and external rotation from stretching muscle groups of the anterior shoulder girdle, that might facilitate reach height.

Though there appears to be some benefit of stretching to simply gain muscle length and improve joint ROM, it does not necessarily translate to preventing injury as many have previously believed (Behm & Chaouachi, 2011). Pope et al. (1998) and Pope et al. (2000) tested a total number of 2631 army recruits between them in order to see if there may be an association between pre-activity stretching and the occurrence of injury. Pope et al. (1998) determined that while an ankle dorsiflexion ROM of 34° or less increased the likelihood of injury by 2.5 times, there was no significant reduction in the chances of an injury occurring in those with less than 34° of ankle dorsiflexion from stretching alone (likelihood ratio = 0.09).

There has also been some debate about the effects of static stretching on force production of muscles of the lower body. A few studies have illustrated that on average, a decrease of between 3.2% - 28% can occur in isometric muscle force for up to 120 minutes following static stretching (Fowles et al., 2000; Marek et al., 2005; Power et al., 2004), while others found there to be no effect (Behm et al., 2006; Behm, Bambury, Cahill, & Power, 2004). Fowles et al. (2000) looked solely at the effects of stretching the plantarflexors, though it was not determined whether the dominant or non-dominant side was tested, whereas Marek et al. (2005) combined 3 different methods of stretching just the quadriceps of the dominant leg. Power et al. (2004), Behm et al. (2004) and Behm et al. (2006) included stretching of both the plantarflexors and quadriceps as well as the hamstrings in each participant. Fowles et al. (2000) carried out two different experiments on their participants. They wanted to examine the effects of a series of 13 passive stretches of the ankle dorsiflexor muscles, held for 5-10 seconds per stretch, on the contractile response of the muscles. Experiment 1 tested isometric maximum force production with the ankle held at 10° of dorsiflexion. Three weeks following this initial testing, experiment 2 was performed where the ankle was held at 0°, 10°, and 20° of dorsiflexion. Experiment 2 was used in order to evaluate the contractile abilities of the muscle following stretching at differing joint angles. Post-intervention testing resulted in a significant decrease of 28% in isometric maximum voluntary contraction immediately post stretching. This decrease was still evident for up to 60 minutes, where MVC was still 9% below the pre-testing value. No major differences were found between the two experiments, indicating joint angle of the ankle has limited influence on the contractile abilities of the plantarflexors. In contrast to the findings of Fowles et al. (2000), Power et al. (2004) determined that stretching of the plantarflexors did not produce a change in the MVC in their similar study. This difference may be due to the participants actively carrying out the stretching protocol, rather than a passive application applied by Fowles et al. (2000). Power et al. (2004) did however report a significant decrease of 9.5% in MVC of the quadriceps following an intervention combining both active and passive stretches. This decrease lasted for the testing duration of 120 minutes. The stretching intervention did not change in the pariticpants jump height (Power et al., 2004). In support of these findings, Marek et al. (2005) found a significant decrease of 1.9 Nm in peak torque and 13.4 W in mean power output of the quadriceps at a maximal contraction of $300°\cdot s^{-1}$ following a three-part stretching intervention that included both active and passive stretches. The decrease was greater when the velocity of contraction was performed at $300°\cdot s^{-1}$ compared to at $60°\cdot s^{-1}$, where differences of 0.3 Nm and 0.6 W occurred between pre- and post-stretching performed at the rapid and slow angular velocities respectively. Though majority of studies have shown no effect of stretching on muscular strength or power, two studies suggest a possible deficit by finding non significant 6.5-6.9% deficits in MVC following a 3-part stretching intervention of the quadriceps, hamstrings and plantarflexors bilaterally. While Fowles et al. (2000) utilised only unassisted stretching, both Power et al. (2004) and Marek et al. (2005) employed a combination of both assisted and unassisted stretches. This means we cannot determine whether one style is more effective than the other.

All of the these studies utilised a different apparatus in order to record their measurements, which all included an aspect of securing the participants lower body and allowed for force to be exerted against the apparatus (Behm et al., 2006, 2004; Fowles et al., 2000; Marek et al., 2005; Power et al., 2004). Having the participants seated while performing their maximal voluntary contractions may provide greater standardisation of technique, but does not provide a good representation of how stretching may decrease force output during jumping. Power et al. (2004) and Behm et al. (2006) also included a drop jump as another aspect of testing. Both determined there to be no significant change in jump height for up to 120 minutes following the stretching intervention. Therefore, although there is evidence to suggest MVC may decrease from static stretching, this does not necessarily translate into a decline in jumping performance.

## Shoulder Immobility

While there is a moderate amount of research surrounding lower body training and the benefits of including an arm swing during the jumping movement, a search of both Google Scholar and Pubmed identified little research that has investigated the effects of the shoulder on an individual's ability to reach during vertical jumping. However, there have been numerous studies examining muscular imbalances and ROM in the dominant arm, primarily the shoulder, of baseball pitchers (Page, 2011; Wilk et al., 2011, 2015) and elite volleyball players (Forthomme et al., 2005; Reeser et al., 2010; Wang & Cochrane, 2000, 2001). A common finding that has emerged from these studies is the existence of a glenohumeral internal rotation deficiency (GIRD), accompanied by an increase in glenohumeral external rotation. Most commonly, GIRD is believed to be a result of tension forming in the posterior capsule of the shoulder caused by repetitive microtrauma during the deceleration stage of throwing (Burkhart, Morgan, & Ben Kibler, 2003; Wang & Cochrane, 2000) or repetitive spiking motions in volleyball (Forthomme et al., 2005). Poor posture is another factor shown to hinder shoulder mobility. Greenfield et al. (1995) mentions that a forward head posture and rounded shoulders can change the orientation of the scapula, eventually leading to muscle imbalances in the shoulder and an overall decrease in ROM. Fleisig, Barrentine, Escamilla, and Andrews (1996) established a connection between the actions occurring in basketball, netball, volleyball and baseball players during a game . They highlight the idea of a commonly occurring sequence of movements from the pelvis to the shoulder in order to generate the required eccentric loading during any overhead throw. Therefore, studies undertaken on baseball and volleyball players could also relate to basketball and netball players.

*Glenohumeral Internal Rotation Deficiency (GIRD)*

Recent research has drawn upon findings surrounding dysfunctional shoulder movement in athletes, and has examined the relationship between shoulder immobility and injury and pain. Wilk et al. (2011) concluded that a total rotational motion deficit of greater than 5° in the dominant arm of baseball pitchers resulted in a significant increase in the probability of an injury occurring. Additionally, the authors observed that the pitchers who presented with GIRD were almost twice as likely to develop a shoulder injury (Wilk et al., 2011). Wang and Cochrane (2001) also found significant evidence to link shoulder problems with an imbalance in isometric motor function between internal and external rotation of the shoulder in volleyball players. Wilk et al. (2015) found evidence to contradict his previous findings. They observed that the presence of GIRD had no significant association on the probability of a shoulder injury developing. In contrast to the reduced internal rotation observed in GIRD, the likelihood of requiring surgery in this study increased 4 times in those with insufficient external rotation of the shoulder. While the results of these studies are contradictory with respect to the type of movement restricted, they both provide evidence to support the theory that if left untreated, shoulder dysfunction due to repetitive overhead motion can lead to further injury. Therefore, it is likely that treatment of the shoulder and surrounding musculature aimed at improving ROM and decreasing tissue hypertonicity would be beneficial as an injury prevention approach.

*Posture*

Posture is another area that needs to be considered when investigating the reasons why the shoulder may be experiencing a decrease in ROM. The link between posture and ROM is due to the relationship between the shoulder and thoracic spine through the scapulothoracic joint. Greenfield et al. (1995) conducted a study exploring this link in 60 participants, comparing healthy shoulders to those with shoulder overuse injuries and insidious shoulder pain. They concluded that abnormal alignment through the thoracic and cervical spine could change the resting position of the scapula, with no significant difference between the healthy and injured shoulders. An exaggerated thoracic kyphosis often results in protraction as well as downward rotation of the scapulae bilaterally (Greenfield et al., 1995). This change in scapula orientation leads to an inferior shift of the glenoid fossa and acromion process (Greenfield et al., 1995). A consequence of this shift is internal rotation of the humerus on the glenoid, along with a decrease in the subacromial space (Bullock, Foster, & Wright, 2005). When an individual then abducts the arm, the movement is limited by the abnormal positioning of the acromion process, resulting in a decrease in ROM (Edmondston et al., 2012).

Shoulder girdle ROM is limited in slouched compared to erect posture in both healthy participants and in individuals with shoulder pain or dysfunction (Kebaetse, McClure, & Pratt, 1999). Kebaetse, McClure, and Pratt (1999) carried out a study on 34 healthy subjects to determine the effect of thoracic posture on movements of the shoulder and scapulothoracic joint. They discovered with the subject in a slouched posture, the ROM of active shoulder abduction decreased by an average of 23.6°. The subjects also exhibited a 16% decrease in muscular force during active resisted horizontal abduction (Kebaetse et al., 1999). A secondary aim of the study was to investigate the scapular movement patterns during both an erect and slouched posture. Whilst the results showed no difference in scapula rotation between 0° – 90° of shoulder abduction, there was significantly less scapula rotation between 90° – maximum shoulder abduction when the subject maintained a slouched thoracic posture (Kebaetse et al., 1999). These results help to reinforce the importance of a correct posture and ROM through the thoracic spine in order to achieve maximal ROM of the shoulder, incorporating optimal upward scapula rotation, especially during full abduction. Bullock et al. (2005) conducted a study with a similar outcome on 28 individuals with shoulder pain or dysfunction. They found a significant difference in active shoulder flexion between the postures, with a mean maximum of 109.7±25.53° shoulder flexion in a slumped posture and 127.3±25.81° when sitting erect (Bullock et al., 2005).

*Gender differences*

Throughout the literature, a common theme that has arisen is that females tend to have greater mobility through the shoulder (Chung & Wang, 2009; Merrill et al., 2009). Data from Chung and Wang (2009) shows that females are predisposed to having greater ROM than males, particularly through extension of the shoulder (56±12.9° males to 58±13.1° females) and side bending left (41±10.6° to 43.2±10.4°), right (42.3±11° to 47.1±10.8°) and rotation through the cervical spine (72.3±10.1° to 74.1±10.2°). This is thought to be due to greater compliance (laxity) of the ligaments surrounding the joint (Lephart, Ferris, Riemann, Myers, & Fu, 2002) caused by higher levels of estrogen and progresterone (Heitz, Eisenman, Beck, & Walker, 1999). Another reason for females having increased mobility over males may be the anatomical structure of the glenoid itself. Merrill, Guzman, and Miller (2009) investigated the glenoid fossa in 368 human scapula bones. They found a significant difference in the shape of the glenoid between the two genders. Females tend to have a smaller, more rounded, oval shaped glenoid. This can cause a change in the orientation of the head of the humerus in the joint socket, thus having an effect on shoulder ROM by decreasing joint stability.

While females may have greater ROM through the shoulder and thoracic spine, they tend to have less strength in the lower extremities compared to males (Frontera et al., 1991). Frontera, Hughes, Lutz, and Evans (1991) conducted a study involving 200 male and female healthy individuals to demonstrate the difference. They found that at faster velocity (240°/s compared to 60°/s), the female participants only had 58.7% the strength of men in the lower extremities during a concentric contraction. This may be relevant to gender differences in jump height as it alludes to the idea that females may not have the same explosive power as males. It may also mean that the degree of upper body reach allowed by shoulder mobility is relatively more important for female jumpers. Findings of gender differences in ROM give validity to the selection of a single sex sample for studies involving improvement of upper body mobility as the outcomes of the testing may vary due to the differences in anatomical and physiological make-up of the genders.

## Osteopathy

Osteopathy is a form of manual therapy that incorporates various techniques that are all aimed at encouraging optimal ROM and the reduction of pain in musculoskeletal structures of the human body (Wright & Sluka, 2001). Three of the most commonly used techniques include muscle energy technique (MET), soft tissue (ST) and high velocity low amplitude thrust (HVLA) applied to various joints, muscles and connective tissue. It is understood that these techniques promote lymphatic drainage, blood flow and trans-synovial flow (Fryer, 2000). HVLA may also be used as a way to quickly and effectively stretch the joint capsule and ligaments in order to increase the ROM of a restricted joint (Fryer, 2000). By increasing blood flow and removing joint restrictions, the sympathetic activity and nociceptor activity of the area should decrease, thus decreasing inflammation and tenderness of the area.

*Muscle Energy Technique*

MET is a gentle manipulative stretching technique used by osteopaths to decrease the hypertonicity of muscles and fascia in order to improve the ROM of dysfunctional joints. It can be performed to both peripheral joints and spinal segments (Burns & Wells, 2006). To achieve this, the practitioner takes the affected muscle to a point where a sense of tension is noted. The patient then moderately contracts the muscle against the practitioner's resistance for 3 – 5 seconds. Upon relaxation, the muscle is taken further into stretch and the process is repeated (Burns & Wells, 2006).

The pathophysiology that explains how MET is beneficial in the relaxation of muscles is not fully understood (Fryer, 2011). One theory is that the stretch and contraction relationship formed by carrying out an MET may assist with drainage of lymph and pro-inflammatory cytokines, thus desensitizing peripheral nociceptors, diminishing tissue hyperalgesia and increasing myofascial tissue extensibility (Fryer, 2011). This theory is supported by Havas et al. (1997), who observed that during the stretching phase, the lymphatic vessels are opened and the fluid can enter the vessels. Upon contraction of the muscle, the lymphatic vessels close, forcing the fluid proximally. As previously stated, the process of removing lymphatic fluid desensitizes peripheral nociceptos, decreasing tissue hyperalgesia and increasing myofascial tissue extensibility, thus potentially increasing joint ROM (Fryer, 2011).

Several articles examine the effects of MET on ROM of the different areas of the spinal column. One paper written by Lenehan, Fryer, and McLaughlin, (2003) looked into the changes in gross thoracic ROM, while Burns & Wells (2006) and Schenk, Adelman, and Rousselle (1994) examined the effects on the different vectors of movement of the cervical spine. Lenehan et al. (2003) and Burns and Wells (2006) were interested in the immediate effects of a single session that involved three repetitions of MET to the restricted segments. Schenk et al. (1994) looked at the lasting effects, performing seven sessions consisting of 3 repetitions over a 4-week period. Post-testing measurements were then taken the day after the final session was completed. All three studies included a control group or condition. Burns and Wells (2006) performed a sham MET treatment on the cervical spine, where the participant's head was passively moved into a barrier, but no isometric contraction was performed. Lenehan et al. (2003) did not perform any form of intervention on the control group. They simply waited for 10 minutes between the pre- and post-testing measurements. This may not have been the best method, as participants were not blinded to treatment allocation, as it is easy to determine which is the intervention and control. Though results of a control group are reported, there was no description of this control group from Schenk et al. (1994). There were significant increases in ROM in both the thoracic spine (Lenehan et al., 2003) and cervical spine (Burns & Wells, 2006; Schenk et al., 1994) following the intervention. Lenehan et al. (2003) observed a 10.7° increase in gross thoracic rotation in the direction that was deemed restricted when originally tested, compared to no effect on the control group, or when it was performed in a direction that was deemed unrestricted. MET to improve rotation of the cervical spine was also shown to be effective by both Burns and Wells (2006) and Schenk et al. (1994). Side bending ROM significantly improved according to Burns and Wells (2006), however there was no effect on either flexion or extension ROM. Although Schenk et al. (1994) noticed a strong trend in improvements of left rotation (65.3°±7.3° to 73.1°±6.5°), right rotation (60.4°±10.4° to 69.4°±6.1°) and side-bending to the right (35.2°±8.4° to 43.4°±6.0°), there was no significant change in either left side bending, flexion or extension. Burns and Wells (2006) explained that this may be because there is no physical barrier during a rotation movement of the neck, whereas the shoulder and chest can interfere with the movements of flexion and side bending. However this theory does not explain why there were improvements in right side bending. Schenk et al. (1994) provided a different explanation. They noticed during testing that although flexion and side bending movements were included as vectors in order to find a barrier, the primary isometric contraction force executed by the patient during the MET was a rotation direction. Thus, the consequent relaxation of the musculature would occur primarily to the rotator muscles of the cervical spine. Although these results do not pertain to the peripheral joints, it supports the use of MET in order to increase muscle extensibility and thus increase joint ROM.

MET is not only specific for the spinal column. The technique may also be used to improve ROM in the peripheral joints (Moore et al., 2011; Shadmehr et al., 2009). Moore et al. (2011) determined the effects of MET on horizontal adduction and internal rotation of the glenohumeral joint of 61 baseball players and compared them to a control group who received no treatment between the testing. The results demonstrate a significant increase of 4.2±5.3° in internal rotation and a 6.8±10.5°

increase in horizontal adduction of the glenohumeral joint directly following a single application of MET (Moore et al., 2011). Similar outcomes were found by Shadmehr et al. (2009), who examined 30 women with restricted extension of the lower leg due to hamstring tightness. Immediately following a series of three repetitions in a single session, there was a significant 22° increase in the mean scores. However, the control group in this trial was instructed to perform a static hamstring stretch for 30 seconds, three times per week for four weeks and appeared to have similar results. There was an average improvement of 18.6° which was also significant (Shadmehr et al., 2009). Although MET and static stretching of the hamstrings appear to have similar effects, MET to the muscles was performed only once, while the hamstring stretch was regularly carried out by the individual for a longer duration, thus MET may be beneficial as an acute method of increasing ROM.

*Soft Tissue*

ST massage incompasses a range of technique commonly employed by osteopaths and manual therapists to treat hypertonicity occurring in muscles (Campbell, Winkelmann, & Walkowski, 2012). Muscle hypertonicity manifests as what is known as myofascial trigger points. One cause of these trigger points is when damage occurs to sarcoplasmic reticulum when the muscle is overloaded (Bron & Dommerholt, 2012). This can result in a consequent release of large amounts of calcium ions and a disturbance of cytoskeletal proteins (Bron & Dommerholt, 2012). Sandler (1999) proposed that chemical agents, bradykinin, histamine and Lewis's P substance, are released during muscle damage. These chemicals then stimulate the local pain receptor nerve endings, eliciting pain in the muscle (Sandler, 1999). Another theory is that during a sustained muscular contraction of at least 10% of the maximal voluntary contraction, the capillary blood flow is momentarily restricted (Bron & Dommerholt, 2012). This limits the oxygen and glucose available to the muscle, thus anaerobic glycolysis occurs, resulting in the production of lactic acid (Bron & Dommerholt, 2012). Due to the constriction of the capillary blood flow, this lactic acid build up remains in the tissue, decreasing the overall pH of the intramuscular acidity (Bron & Dommerholt, 2012). This change in pH increases the nociceptive stimulation of the muscle fibres, resulting in a lower pain threshold (Bron & Dommerholt, 2012). A low pH also increases the activity of acetylcholine while simultaneously decreasing the efficacy of acetylcholinesterase, resulting in the sustained contraction of the sarcomere and the feeling of hypertonicity of the muscle (Bron & Dommerholt, 2012). Massage may be effective in countering these effects by increasing blood flow and fluid drainage.

A comparison of two different styles of ST massage for the treatment of pain resulting from myofascial trigger points in the cervical spine was carried out in a study by (Fernández-de-las-Peñas, Alonso-Blanco, Fernández-Carnero, & Carlos Miangolarra-Page, 2006). The first group received ischemic compression technique, where pressure was applied to the trigger point by the therapist until pain is felt, and is then held for approximately 90 seconds. The second style of ST performed was transverse friction rub with minimal details describing the application of this technique. Both treatment groups had a significant decrease in both pain and pressure scores, and results were fairly similar. Group One, who received the ischaemic compression technique, had a marginally better outcome than those who received transverse friction rub technique. They incurred a 0.8 decrease in the mean VAS scores from 4.6±1.2 cm to 3.8±0.9 cm, and a 0.4 kg/cm$^2$ increase of the mean pressure required to elicit pain, from 1.8±0.5 kg/cm$^2$ to 2.2±0.6 kg/cm$^2$ (Fernández-de-las-Peñas et al., 2006). Group Two showed similar outcomes with a 0.7 decrease in the mean VAS scores and a 0.35 kg/cm$^2$ increase in mean pressure pain threshold following traverse frictioning. Despite having a positive outcome in both treatment groups, Fernández-de-las-Peñas et al. (2006) did not include either a sham or no treatment control. This makes it difficult to ascertain whether it was the treatment itself that was effective in the reduction of the trigger points, or whether it was a placebo effect based on just receiving any form of therapy.

Analysis of the literature has also demonstrated a positive outcome for ST when applied to the shoulder. Van den Dolder and Roberts (2003) examined the shoulders of 29 participants between the ages of 54 and 75 years presenting with trigger points, who were then randomised into either a treatment group or a control group. The treatment group received six ST treatments over a two week period focusing on the muscles surrounding the glenohumeral joint, while a control group were lead to believe they were on a “waiting list”, and received no treatment at any stage (Van den

Dolder & Roberts, 2003). The participants' pain levels were measured using the Short-form McGill Pain Questionnaire (SFMPQ) method, consisting of a description of the pain quality, a Visual Analogue Scale (VAS) and the Present Pain Index (PPI). Active shoulder flexion and abduction were also measured. The patients in the treatment group had a significant decrease in the mean SFMPQ pain score from 58.4±22.7 to 31.8±26.4 on a scale of 100. They also gained greater shoulder ROM following treatment, with an average increase of 33.4° in abduction and 15.1° in flexion (Van den Dolder & Roberts, 2003). There were no significant changes in any of the measurements taken in the control group.

While majority of the published literature has demonstrated ST massage to have a positive effect on patients pain and disability measures, Cambron, Dexheimer, Coe, & Swenson (2007) brought to light the negative side-effects that can also occur. They conducted a survey involving 91 participants to ascertain whether anyone had a negative experience. The most common side-effect was found to be a general increase in discomfort and soreness, as described by 9.9% of the participants (Cambron et al., 2007). Bruising, headaches and fatigue were also reported, however only 3.3% of the participants experienced any one of these side effects and none lasted for more than 36 hours following the intervention. This study did not assess the effects of ST on ROM of any area, however 2.2% did notice a self-perceived improvement in their posture, and 9.9% noticed an increase in their overall mood and wellbeing (Cambron et al., 2007).

*High Velocity Low Amplitude Thrust*

HVLA thrusts are frequently used to treat dysfunction within joints of the spinal column, which most commonly occur due to somatic dysfunction. Somatic dysfunction can be defined as "impaired or altered function of related components of the somatic (body framework) system: skeletal, arthrodial and myofascial structures, and their related vascular, lymphatic, and neural elements" (Ward & Sprafka, 2002, p 53). When a somatic or visceral structure is injured, it produces contradictory afferent impulses to the dorsal horn in the spinal column (Fryer, 2000). The spinal interneuron thresholds are decreased, resulting in a sensitisation of that segment. The common presentation of somatic dysfunction can be broken down into four different components. These include changes in tissue texture such as hypertonicity, asymmetry, restricted ROM and tenderness in the affected area (Somatic Dysfunction in Osteopathic Family Medicine, 2007). Tissue inflammation and sympathetic stimulation are further increased, thus the cycle becomes self-sustaining and the pain becomes chronic.

Somatic dysfunction often occurs due to strain of the zygopophysial joint ligament or capsule in the spinal column (Fryer, 2000). Inflammation and synovial effusion of the segment occurs, resulting in the nociceptor activation. Action potentials are sent to the dorsal horn, stimulating sympathetic activation and triggering reflexive inhibition to stabilising muscles such as multifidus. Polysegmental muscles such as erector spinae are consequently excited to compensate, however, do not have the same stabilising tonic contraction abilities, thus the joint is more vulnerable to further strain. Over time, it is believed that fibrosis and thickening of the zygapophysial joint capsule occurs, leading to the presence of chronic joint restrictions and tissue tenderness (Fryer, 2000).

The mechanics of performing an HVLA thrust have been described by (Herzog, 2010). The targeted joint is taken into ‘bind’, a point where the practitioner feels is its end of range of movement. This point is known as the preload force. A force thrust is then performed with the velocity and direction determined by the practitioner based on the previous examination findings (Bronfort, Haas, Evans, Kawchuk, & Dagenais, 2008). As the articular surfaces of the targeted joint momentarily move apart, a change in pressure within the joint occurs. This results in the formation and break down of small gas bubbles. This process is thought to be responsible for the audible ‘crack’ or ‘pop’ that is often associated with the thrust (Bronfort et al., 2008).

HVLA performed to the thoracic spine has been demonstrated by a number of authors to ease shoulder pain and increase ROM (Boyles et al., 2009; Haik et al., 2014; Winters, Sobel, Groenier, Arendzen, & Meyboom-de Jong, 1997). Thoracic and cervical spine manipulation was compared to corticosteroid injections and general physiotherapy techniques such as exercise therapy and massage for the treatment of shoulder pain in a single blind study (Winters et al., 1997). The 172 participants were split into three groups based on their results following a physical examination. The diagnosis was either synovial dysfunction, shoulder girdle dysfunction, or a combination of the two. The participants were then randomly allocated to treatment. Pain scores were taken 11 weeks following the initial intervention. The participants were asked 6 questions, which were then scored on a 4-point scale of severity, resulting in an overall pain score ranging from 7 points (no pain) to 28 points (severe pain). With a decrease of 6.1, the manipulation was deemed to be more effective than physiotherapy plus anti-inflammatories (4.8 decrease) in terms of reducing the average pain score in those diagnosed with shoulder girdle dysfunction (Winters et al., 1997). However, in the synovial dysfunction group, corticosteroid injections showed more rapid improvements than the manipulation group. Three quarters of the patients experienced a disappearance of shoulder pain with an average decrease in pain scores from 16.3±4.8 to 8.3±1.7. Only 40% of those who received the manipulation treatment were deemed 'cured', with an average pain score of 8.9 following treatment. Boyles et al. (2009) and Haik et al. (2014) both explored the short-term effects of thoracic spine manipulation on patients diagnosed with shoulder impingement syndrome. The 56 participants involved in the study by Boyles et al. (2009) all received the thoracic spine manipulation. The results give a good indication that the intervention may help to reduce pain and disability scores in those affected by shoulder impingement syndrome, showing a significant 6.8 decrease on the Shoulder Pain and Disability Index (SPADI) over the 48 hours following the intervention. Despite the positive results, there was no control group to compare the findings, therefore a causative link between the therapy and outcome is uncertain (Boyles et al., 2009). Although Haik et al. (2014) did include a control group that received a sham treatment where no manipulation was achieved, there was no significant difference between the intervention and control groups in pain reduction during arm movements in the immediate follow up testing. However, a significant increase in scapular internal rotation was observed in those with shoulder impingement syndrome who received thoracic spine manipulation compared to control. As described by Kebaetse et al. (1999) changes in ROM of the scapula can directly influence shoulder mobility. Although shoulder ROM measurements were not taken by Haik et al. (2014) in this study, based on the scapula changes, it is possible shoulder ROM of the participants may have increased. Therefore, the original hypothesis put forward by Haik et al.

(2014), that manipulation might be a worthwhile treatment for this condition, cannot be completely disregarded.

In addition to application to the thoracic spine, HVLA applied to the upper rib heads has also been shown to have a positive effect on reducing pain and disability in patients with shoulder dysfunction (Chitroda & Heggannavar, 2014; Dunning et al., 2015). In an randomized controlled trial, Dunning et al. (2015) hypothesised that a combination of thoracic and upper rib head manipulation may help to decrease pain and disability of the shoulder. 10 participants presenting with unilateral shoulder pain were included in the study. Two sessions of HVLA to the rib heads were administered with 48 hours between each. Immediately following the intervention, numeric pain rating scores decreased from 6.5±1.8 to 2.5±1.6. There was also a significant decrease from 50.3±17.9 to 11.1±10.2 in the SPADI scores. While these data are promising, due to the small sample size of 10 participants and lack of a control group, it is difficult to determine a cause and effect relationship (Dunning et al., 2015).

Chitroda and Heggannavar (2014) had a similar aim. They wanted to examine how thoracic spine and upper rib manipulation could influence shoulder girdle pain secondary to rib dysfunction. The intervention included one thrust to the second and third rib heads in the initial treatment session. This was compared to a control group who received transcutaneous electrical nerve stimulation (TENS) therapy and exercises. Outcome measures were taken 48 hours post-intervention, and a manipulation to the second and third thoracic segments was then applied for the second treatment session. While both interventions did result in a significant improvement in shoulder ROM in all vectors as well as a decrease in VAS scores, those who received thoracic and rib head manipulation had a greater improvement in all areas. The mean VAS score decreased from 7.6±0.27 cm pre-treatment to 1.9±0.69 cm post treatment compared to a smaller decrease from 7.3±1.05 cm pre-treatment to 3.3±1.02 cm of the control group (Chitroda & Heggannavar, 2014). These scores were retained for up to 3 months. There was also a significant increase ROM immediately following intervention in all planes of movement of the shoulder, the greatest being an average increase of 51.5% in internal rotation.

HVLA of the thoracic spine and rib heads appears to be an effective method of achieving an increase in shoulder ROM and decreasing shoulder pain and dysfunction. However, the studies presented above (Boyles et al., 2009; Chitroda & Heggannavar, 2014; Haik et al., 2014) only examine the the effects of treatment over the course of several sessions. Therefore, it is unknown whether a single session will have similar acute effects.

## Conclusion

The importance of being able to jump high during overhead sports is well recognised. This is shown in the vast amount of research published surrounding jumping mechanics and determining the best method of improving vertical jump height. Despite the evidence asserting the benefits an arm swing can have during the jumping phase (Feltner et al., 1999; Harman et al., 1989), there is scarcely any research examining the importance of also having optimal shoulder function in order to increase the individuals reach height during a jump. Research on the potential effects of different osteopathic techniques for addressing shoulder function is also limited. However, there is evidence to illustrate that certain techniques can improve body mechanics by decreasing muscular tension and increasing ROM of various joints. Based on the literature examined above, there is indication that an osteopathic treatment to improve shoulder mobility in overhead sports players in order to achieve a greater jump reach is warranted. Research investigating the efficacy of such treatment is therefore required.

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# Section 2

# 'Manuscript'

**Note:** This manuscript has been prepared and formatted following instruction of the Journal of Strength and Conditioning Research, which can be found here: http://edmgr.ovid.com/jscr/accounts/ifauth.htm. For the purposes of the Masters thesis I have included the tables and figures in text rather than at the end of the document. APA referencing and 1.5 line spacing has been continued throughout the manuscript following the literature review in order to maintain consistency for the reader, rather than the recommended style by the Journal of Strength and Conditioning Research.

# Effects of a short-term osteopathic intervention on vertical jump and reach height in female recreational overhead athletes

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## ABSTRACT

Lower body training to improve jump height for sport performance has been extensively researched. However, no research has investigated improving shoulder range of motion through osteopathic techniques in order to achieve optimal overhead jump reach. The aim of this study was to investigate the effects of an osteopathic intervention for shoulder and thoracic range of motion in female athletes on overhead reach during vertical jumping. Participants were 17 healthy, active women (aged 18–37 years) who were involved in basketball (n=9), netball (n=7) or volleyball (n=1). In a crossover design, they received an upper and lower body osteopathic intervention, in randomised order, 1 week apart. Jump reach and maximum ground reaction force (GRF) with and without arm swing were recorded prior to and immediately following each intervention using a Swift Yardstick$^{TM}$ Vertical Jump Tester and force plate. There was no meaningful difference between interventions in the change in jump height following each intervention (P=0.96). However, there was a significant change in standing reach height following the upper body intervention (P=0.04), from 211.0±6.5 cm to 214.0±6.4 cm (mean±SD). An arm swing increased GRF during jumping from 1473 N [95% confidence interval 1328 to 1619 N] to 1660 N [1466 to 1854 N]. Overhead jump reach did not improve with osteopathic techniques for shoulder mobility in young, active women. Despite this, a significant increase in standing reach height was observed, suggesting that osteopathic techniques may be beneficial when used to improve joint ROM.



*Key Words:* Shoulder; Range of Motion; Jumping; Athletic Performance; Osteopathy;

# INTRODUCTION

An athlete's ability to jump and reach higher is a crucial skill in overhead sports such as basketball, netball and volleyball at both professional and social levels (Bobbert & Van Soest, 1994). The importance is reflected in the numerous research studies that have investigated the most effective method of training to achieve optimal vertical jump height. Increasing strength of the lower extremities through plyometric training appears to be the most effective approach. It has been shown to increase the maximal force production and explosive power of the legs by between 3 – 20 % (Luebbers et al., 2003; Maffiuletti et al., 2002), thus increasing the individual's jumping ability (Bobbert, 1990; Gehri et al., 1998; Saez de Villarreal et al., 2009; Sheppard et al., 2011). Other less researched approaches to improving vertical jump height include the use of whole body vibration (Cardinale & Lim, 2003) and the effects of modified athletic training shoes with raised forefoot platforms, such as the Meridian shoe™ (Kraemer, Ratamess, Volek, Mazzetti, & Gomez, 2000).

One area that has been neglected is the impact the upper body can have on jumping ability. It is known that the inclusion of an arm swing while performing a vertical jump can significantly increase the vertical ground reaction force (GRF) produced as well as the overall jump height (Blache & Monteil, 2013; Hara et al., 2001; Harman et al., 1989; Shetty & Etnyre, 1989). There are also studies that report limitations of 8.9° – 18.0° in shoulder mobility of male and female athletes who perform repetitive overhead arm movements, such as basketball, netball and volleyball players (Reeser et al., 2010; Wang & Cochrane, 2000; Wilk et al., 2011). Despite this, there is limited research to show relationships between increased shoulder and thoracic spine range of motion (ROM) and an increased ability to reach higher when jumping.

Research on the improvement of jump reach involving female athletes is even more limited. Females are inclined to have a more rounded, oval shaped glenoid fossa in comparison to males (Merrill et al., 2009), as well as greater flexibility and ROM of joints (Lephart et al., 2002). This provides justification to study female athletes separately.

Static stretching of major muscle groups is another strategy that is commonly employed by coaches and sports players in order to improve sports performance and prevent injury (Behm & Chaouachi, 2011). Taking a limb to its end range of movement is thought to decrease the stiffness of the musculotendinous unit and increase the overall length of the muscles responsible for the movement of that joint (Behm & Chaouachi, 2011). Improving muscle length has been assumed to decrease the likelihood of the muscle being overstretched and suffering from tears in the muscle fibres (Bandy & Irion, 1994; Behm & Chaouachi, 2011). Recent research draws these views into question. Some authors have found evidence to suggest active stretching can have an acute negative impact on muscle power and output (Fowles et al., 2000; Marek et al., 2005; Power et al., 2004), while others reveal that although increased ROM can reduce predisposition to injury (Cools, Johansson, Borms, & Maenhout, 2015), active stretching is not a beneficial prevention method (Pope et al., 1998, 2000). This conflicting evidence allows for different approaches towards injury prevention and the improvement of ROM to be considered.

Osteopathy is a form of manual therapy that has always focused on the optimisation of joint mobility, pain reduction and injury prevention (Wright & Sluka, 2001). Various techniques such as muscle energy technique (MET), soft tissue (ST) massage and high velocity low amplitude (HVLA) thrusts are used together in order to achieve the best results. They are performed on various joints, muscles and connective tissues of the body and aim to increase blood and lymphatic drainage, increase myofascial tissue extensibility and decrease tissue hyperalgesia (Fryer, 2011). Ample literature provides evidence to support the efficacy of these techniques for mobility improvement and reduction of pain and disability. Following treatment using these techniques, participants have shown increases in thoracic and shoulder ROM (Dunning et al., 2015; Haik et al., 2014; Lenehan et al., 2003; Moore et al., 2011; Strunce et al., 2009) and decreases in shoulder pain and disability (Chitroda & Heggannavar, 2014; Fernández-de-las-Peñas et al., 2006; Van den Dolder & Roberts, 2003; Winters et al., 1997). Based on the literature examined above, there is indication that an osteopathic intervention to improve shoulder mobility in overhead sports players in order to achieve a greater jump reach is warranted. Therefore, the aim of this study is to investigate the effects of an osteopathic intervention package on shoulder and thoracic ROM in female athletes, with the aim of increasing the overhead reach portion of a vertical jump, using a jump and reach test.

## METHODS

### Experimental Approach to the Problem

This randomised crossover design study compared the short term effects of an upper body osteopathic manual therapy to a lower body control procedure on jump and reach height of female athletes. It was part of a larger study that included both males and females. It was granted ethical approval by the Unitec Research Ethics Committee (UREC 20141093) and registered with the Australia and New Zealand Clinical Trial Registry (ACTRN12615000168550).

### Subjects

Women between 18 and 37 years old were sought for this study. They were recruited through the use of posters, word of mouth, Facebook posts and face-to-face recruitment. They were included in the study if they had currently or recently participated in basketball, netball or volleyball. Participants were not able to take part in this study if they had any previous history of shoulder surgery or serious injury, including frozen shoulder; any shoulder pain affecting shoulder function with a verbal rating score of 1 or above (Holdgate, Asha, Craig, & Thompson, 2003); any current lower extremity or pelvic injuries that may have affected their vertical jump performance; experienced any cardiac or neurological symptoms; been on or were currently on any medication that could have had musculoskeletal side effects such as aspirin; or had received any form of manual therapy to the shoulder or thoracic spine 1 week prior to testing. Each participant received an information sheet (See Appendix A) outlining the study and provided written, informed consent (See Appendix B) before data collection began.

### Randomisation and Blinding

Upon acceptance into the study, the participants were randomly allocated to the order in which they received the intervention and sham intervention using the web-based tool www.random.org. This was carried out by a third party who had no contact with the participants and communicated to the osteopathic practitioner who performed the upper and lower body interventions. The examiner, responsible for taking the participants through the warm-up, instructing them during the jumping phase, and measuring the jump reach and GRF, was blinded to the intervention allocation until the entire data collection process was completed.

Participants were not informed of the existence of a control condition, but were told that the study was comparing the effects of two osteopathic procedures on vertical jump and reach height. Following the conclusion of the study, participants were asked which protocol they thought were effective in increasing jump reach in order to determine the effectiveness of the participant blinding.

**Procedures**

Prior to testing, the weight and height of the participant was recorded at each session. Women's maximum reach heights were then taken with both arms raised above their heads, whilst standing on a force plate [Model 400S Isotronic Force Plate, Fitness Technology, Skye, South Australia, Australia]. Reach height was recorded using a Swift Yardstick™ Vertical Jump Tester [Swift Performance, Wacol, QLD, Australia]. The Yardstick was moved so the zero was the height of the fingertips.

Then the participants underwent a 5-minute standardised warm-up consisting of dynamic stretching aimed at the upper and lower extremities, with no rest between exercises. The exercises included big arm circles (30 seconds clockwise, 30 seconds anti-clockwise); small arm circles (30 seconds clockwise, 30 seconds anticlockwise); windmills with arms for 1 minute; walking lunges for 1 minute; salsa feet for 1 minute.

Directly following the warm-up, participants were instructed to perform three countermovement jumps on the force plate, using a two feet take-off with their arms folded across their chest. They were then instructed to carry out three more vertical jumps on the force plate, this time including an arm swing to reach with both arms as high above their heads as they could, with maximum jump reach height again recorded from the Swift Yardstick™. Values of GRF were measured for every participant during each vertical jump using the force plate. Maximal GRF from the beginning of the countermovement was recorded. The participant then received the intervention allocated for that session, either the upper body intervention or the lower body control intervention. Following this, the jumping procedure was repeated.

## Intervention

*Upper Body Osteopathic Intervention*

With participants side lying on a plinth table, the practitioner applied a longitudinal stretch to Latissimus Dorsi muscle. MET was then applied to the muscles of the shoulder, focusing primarily on improving internal and external rotation and shoulder flexion. This technique was performed bilaterally as both extremities are involved during testing.

The participant was then asked to lie prone in order for cross fibre ST friction/massage/technique to be performed to the Rhomboids, Upper Trapezius and paravertebral muscles in the thoracic region, as well as the Rotator Cuff muscles and Deltoids of the shoulder. This technique was carried out by the practitioner using either the heel of their hand or finger pads, according to their discretion. This technique was performed bilaterally.

With the patient supine, a pin and stretch technique was applied to Pectoralis major and minor muscles bilaterally. This was achieved by the practitioner applying pressure to the belly of the muscle and slowly bringing the participants arm above their head, producing a stretch through the muscle. An HVLA thrust was then applied to the restricted segments of the thoracic spine. The practitioner was allowed to perform up to 3 manipulations on the thoracic spine, depending on the number of restrictions. The segments were limited to the spinal region of T2 – 8 to limit the differences between participants.

*Lower Body Osteopathic Control with Sham Techniques*

The control intervention entailed a broad 'treatment' to the lower extremities. This included a light effleurage to the gastrocnemius and hamstring muscles bilaterally and an ineffective MET to improve inversion and eversion of the ankles bilaterally. The techniques were performed with low intensity to minimise the possibility of any effect.

### Statistical Analyses

All statistical analysis and descriptive statistics were performed using SPSS (Version 23 IBM, Armonk, NY). Means and standard deviations (SD) were used to represent the spread of the data. Assumptions of normality were checked by the examination of z-scores for skewness and kurtosis and the Shapiro-Wilks statistic between pre- and post-intervention outcome variables.

Repeated measures analysis of variance (ANOVA) was used to establish the differences in changes in jump height between the two conditions. An additional analysis included peak vertical GRF to control for differences in peak GRF between the conditions. The level of statistical significance was set at alpha $< 0.05$.

## RESULTS

### Participants

Of the 26 people who expressed interest in taking part in this study, 22 were randomised. Two of the 22 arrived unexpectedly on the testing day and were unable to be randomised centrally but were allocated order by coin toss. Of those randomised, 4 failed to attend the first testing session and 1 attended the first session but was not able to complete the second session. This left 17 people who completed the study with data available for analysis. The flow of the distribution of participants throughout the study is shown in Figure 1. Participant characteristics are shown in Table 1. When questioned as to which intervention the participants found effective, 9 said lower, 2 said upper and 6 thought both were effective.

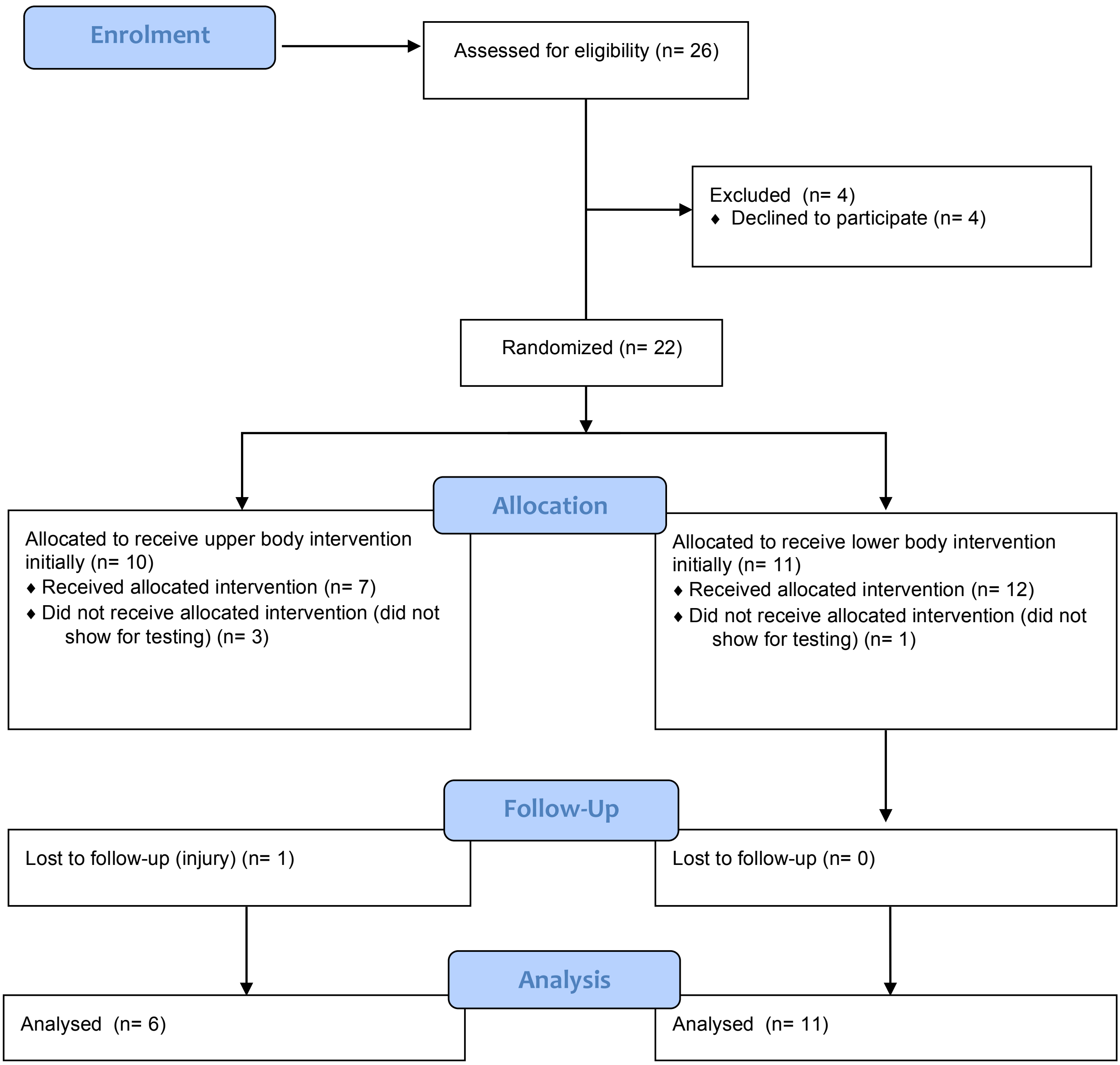


Figure 1. Diagram showing study recruitment flow in CONSORT style (Schulz, Altman, & Moher, 2010).

| | Mean ± SD | Range |
|---|---|---|
| Age (years) | 24 ± 5 | 19 to 35 |
| Weight (kg) | 73.8 ± 15.5 | 57.2 to 124.6 |
| Height (cm) | 172.0 ± 6.4 | 161.1 to 187.6 |
| Reach Height (cm) | 215.4 ± 8.7 | 202.0 to 236.9 |

Table 1. Participant characteristics

**Assumptions of Normality**

Change in jump height from before to after both conditions met assumptions of normality. For change in maximal force with no arm swing, variables showed a high degree of normality, 1 out of 8 variables violated assumptions. Changes in maximal force with arm swing showed evidence of non-normality, with all 8 variables violating assumptions of normality.

**Jump and Reach Height and Standing Arm Reach**

Reliability over the three pre-intervention jumps for both conditions was very high (ICC:3,1 = 0.87), and did not increase over the three jumps ($p = 0.3$ for ANOVA). Using averages of the three arm swing jumps, there was no meaningful difference between interventions in the change in jump height following each intervention ($P=0.96$; Figure 2). During testing it was noticed that participants were quite variable in their motivation to jump.

To determine if the intervention might have had effects in general shoulder mobility, a decision was made during data collection to record standing reach after each intervention as well as before. These data were collected for 11 of the 17 participants, in whom a significant increase in standing reach height following both interventions was shown ($P=0.04$; Figure 3). The control group increased from an average reach height of 211.20±6.72 cm to 212.43±6.18 cm. The intervention group had a larger increase of 211.00±6.53 cm to 214.00±6.40 cm.

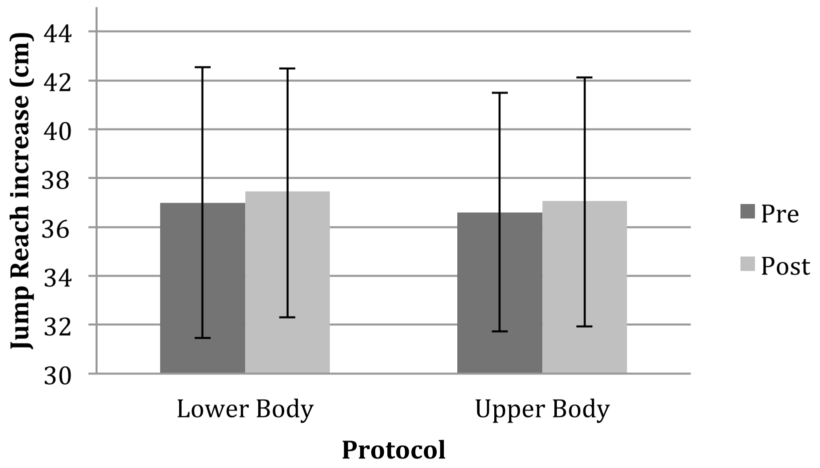


Figure 2. Change in jump and reach height following both interventions.

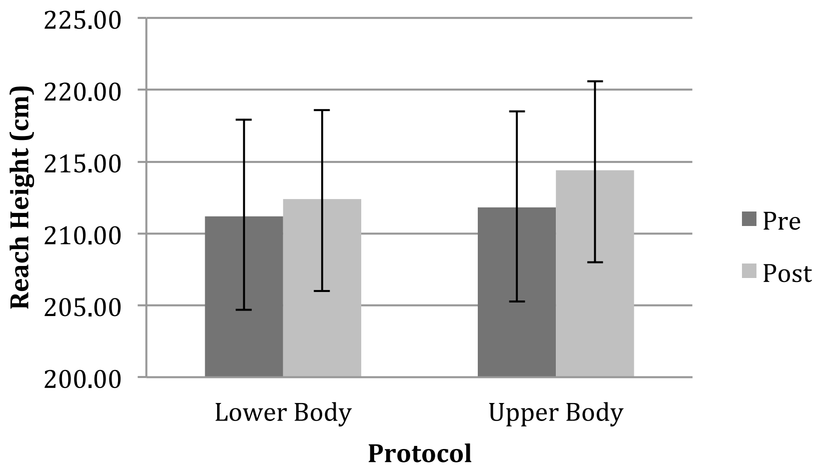


Figure 3. Change in reach height following both interventions.

## Comparison of Arm Swings versus No Arm Swing

A significant difference (P=0.001; Figure 4) was observed between the maximum GRFs in the jumps that included an arm swing compared to those without when included in an ANOVA model that corrected for the effect of time and group. The no arm swings jump mean maximum GRF was 1473 N [95% confidence interval 1328 to 1619 N]. The mean maximum GRF of the arm swings jumping was 1660 N [1466 to 1854 N].

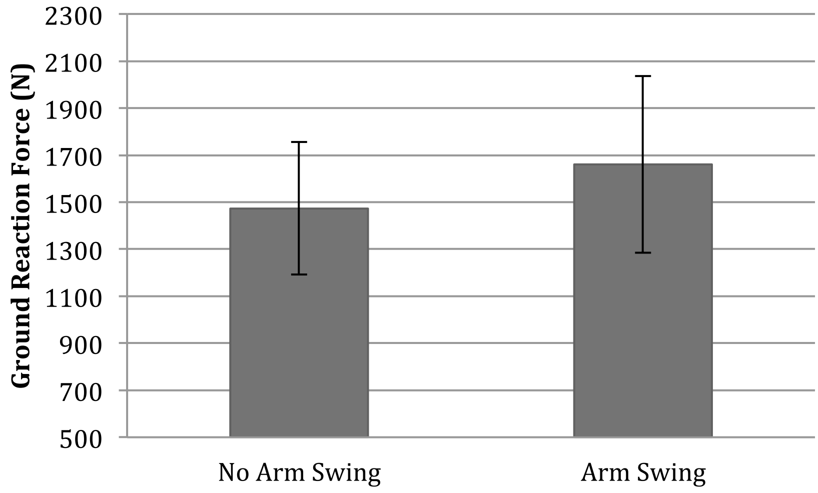


Figure 4. Effect of an arm swing on maximum ground reaction force.

## Discussion

The purpose of this study was to investigate the effects of a standardized osteopathic intervention for shoulder and thoracic ROM in female athletes with the aim of increasing the overhead reach portion of a vertical jump, using a jump and reach test. The main findings determined there to be no significant change in jump reach of 17 female athletes following a standardized osteopathic intervention applied to the upper body. Though there was no improvement in jump reach, there was a significant increase in general shoulder mobility in 11 of the 17 participants in whom this was measured. There was also a 12.7% increase in maximum GRF from the no arm swing to jumps using arm swings. This demonstrates the positive effects the inclusion of an arm swing has on an individual's jumping ability thereby suggesting that a greater ROM in the shoulder may assist with propulsion thus bettering overall jump height.

### Range of Motion

The 1.4% increase noted in standing arm reach height indicates that an increase in shoulder and thoracic ROM may still have occurred following the osteopathic intervention. These results are consistent with the literature which supports that the use of osteopathic techniques including ST, MET and HVLA for improving joint

ROM. Van den Dolder and Roberts (2003) found six 20 minute ST treatments to the musculature of the shoulder to be beneficial in increasing active ROM of the shoulder, with a 32.7% increase in abduction and a 13.2% increase in flexion. Shoulder flexion is the primary axis of movement that determines reach height. Therefore if Van den Dolder and Roberts (2003) had included reach height as a measure, we could postulate an improvement which, given the degree of change in ROM shown, might have been greater than in the present study. The large change in ROM seen by Van den Dolder and Roberts (2003) compared to changes in reach height noted here, may be due to the duration that the ST massage that was performed. Women in the current study received only one ST treatment session that lasted for no longer than 5 minutes. It is possible that this may not have been a sufficient duration to effectively elicit change in the tissues, providing a possible explanation why an increase in jump reach was not achieved.

HVLA of the thoracic spine was performed a maximum of 3 times during a single session in the present study. Greater improvements may have been evident if multiple HVLA thrusts were performed over an extended period of time. Chitroda and Heggannavar (2014) performed HVLA to the thoracic spine in three separate sessions over two weeks. A large increase of 60.7% occurred in shoulder flexion ROM. A similar study by Strunce et al. (2009) showed a lesser improvement of 36% in shoulder flexion following multiple manipulations of the thoracic spine and rib heads over a single treatment session. Although Chitroda and Heggannavar (2014) and Strunce et al. (2009) did not specifically measure reach height, an improvement in this vector of movement would be likely to translate into an increase in reach height. Moore, Laudner, McLoda, and Shaffer (2011) found MET applied to the horizontal abductor muscles of the shoulder seemed to be the most effective in improving glenohumeral internal rotation with a 9.7% increase following 3 applications of MET in a single session. Although internal rotation was not a vector of shoulder ROM that we attempted to improve in the current study, this finding provides support that a single session of MET can be effective.

**Gender Differences**

The lack of effect of the upper body osteopathic intervention on vertical jump and reach height was in contrast to results of the parallel study carried out on 13 male, semi-professional basketball players (Hall, 2016). The results of that study showed significant improvements of an average of 2.8 cm in jump reach following the upper body intervention, compared to a mean decrease of 1 cm following the lower body control intervention. There are a number of reasons why the current study may have failed to identify such effects. The most likely would seem to be the differences in gender. Chung and Wang (2009) established that women are inclined to have greater ROM of their joints compared to men, particularly in shoulder extension (2° difference), and right (4.8°) and left (2.2°) side bending of the cervical spine. This may be due in part to increased laxity and compliance of the ligaments surrounding the joints (Lephart et al., 2002). Another explanation for greater shoulder mobility may be the anatomical the shape of the glenoid itself. According to Merrill, Guzman, and Miller (2009), women tend to have a smaller, more rounded, oval shaped glenoid than men. It is unknown exactly what effect this difference this may have, however it is hypothesized to play a role in changing the orientation of the head of the humerus and in turn influence shoulder ROM. A greater pre-intervention shoulder ROM in the women may have decreased the intervention effects as they already had greater overall joint ROM.

It is also possible that the young women participating in the current study may not have been recruiting 100% of their efforts to reach maximum jump heights. This might have been in contrast to the efforts of the more elite level semi-professional male basketballers recruited by Hall (2016). This theory is supported in the literature from authors examining the differences between genders in sports participation, particularly at younger ages. A common theme that has arisen when looking at adolescents is that on average, young women tend to have less self-esteem and self-concept when partaking in sporting activities in comparison to young men (Klomsten, Skaalvik, & Espnes, 2004; Vilhjalmsson & Kristjansdottir, 2003). Boys have also been suggested to have more of a competitive streak and value sporting achievements more than girls (Vilhjalmsson & Kristjansdottir, 2003). These data were collected via a survey containing questions including time spent performing physical activity, levels of strenuous activity and the importance of sporting achievements. Klomsten et al. (2004) presented a theory that this stems from a history of gender stereotypes and role-typing. From birth, girls are categorized to be weaker and non-athletic, in comparison to boys who are brought up to be strong, dominating and athletic, thus this idea carries through into adulthood. Young women in the current study were not professional athletes and may have had a lesser competitive streak or be less achievement orientated to the jumping task than the male basketballers in the Hall (2016) study. Therefore, the potential to jump and reach higher may have been similarly improved in the current study as to the male participants in the Hall (2016) study, but may not have been realized due to inconsistent motivational factors.

**Effect of Arm Swing**

The findings of the present study show a 12.7% increase in maximum GRF when comparing the jumps without an arm swing to those with an arm swing. These results are in accordance with previously published literature (Blache & Monteil, 2013; Feltner et al., 1999; Hara et al., 2001; Harman et al., 1989). This increase here was greater than published studies by both Harman et al. (1989) and Shetty and Etnyre (1989) who showed an increase of 10% and 6.7% in maximum GRF respectively. Blache and Monteil (2013), Hara et al. (2001) and Lees, Vanrenterghem, and Clercq (2004) did not measure the GRF. They focused instead on the differences in jump height. Blache and Monteil (2013) and Hara et al. (2001) showed increases of 23.7% and 21% respectively in squat jumps. Hara et al. (2001) also included the examination of countermovement movement jumps, as did as Lees et al. (2004), displaying increases of 18.1% and 19.3%.

Hall (2016) noted a 6.5% increase in maximum GRF in men with the inclusion of an arm swing. The increase was less than that observed for the female participants, despite the males showing greater improvements in jump height. Though there is no evidence to explain this gender difference, it is possible that because males appeared, from maximum GRF results (2270 [2070 to 2470] N (mean [95% CI])), to have greater lower body strength compared to women (1158 [1389 to 1727] N (mean [95%

CI])), they may have utilized the strength in the lower body more than the additional propulsion and increased torque provided from the arm swing in order to gain greater reach height than women. Although these are interesting findings, the inclusion of GRF measurement was to ensure the participants were not just recruiting lower body strength and jumping higher, but were in fact reaching higher, therefore these differences should not have influenced the primary results of either study.

The present study did not directly examine the effects of an arm swing versus no arm swing on jump height. However, based on the evidence provided by Blache and Monteil (2013), Hara et al. (2001) and Lees et al. (2004), and the increases in vertical GRF of the participants in the current study, it is possible that jump height may have also increased with the inclusion of an arm swing. This is thought to be due to the increase in torque of the gluteal and quadriceps muscles caused by rotational momentum occurring in the trunk as a result of the upward acceleration of the arms as they are brought up and over the head (Feltner et al., 1999).

**Internal Validity**

In a manual therapy trial, bias between the treatment and control groups may occur due to the expectations of researchers than can also be unwittingly transferred to participants, even when the participants are blinded to the expected effect of the intervention. This randomized controlled trial ensured the examiner was different to the osteopath providing the intervention, and blinded to allocation of the order of interventions, in order to minimize a chance of bias.

An attempt to blind participants to the exact nature of the experiment was made to further increase internal validity. All participants received both the upper and lower body interventions on separate sessions. They were lead to believe the aim of the study was to determine the best method of intervention, and not made aware that the lower body intervention was designed to be ineffective and act as a control. This was reflected by the observation that only two participants did not believe that the lower body intervention was not effective. Based on this feedback, we can be confident that this design appropriately obscured the true aims of the study and added to the reduction of possible bias.

**Limitations**

Within this study, several limitations have been identified. The necessary testing equipment including the Yardstick™ and GRF plate were only available at a single location. This meant that participants who wanted to take part were required to get to the center for testing on two separate occasions and deterred some prospective participants. Due to these difficulties during the recruitment process, the competitive level of the participants was lower than initially desired. Semi-professional athletes were the preferred choice, however most of the participants included in the study played only at a social level. Another limitation was that screening of the shoulder and thoracic spine either prior to or after intervention was not performed and women with full shoulder ROM may have been included in the study. A high ROM prior to the intervention may have reduced the effectiveness of the technique to improve ROM further, which may have resulted in the lack of change in jump reach. The use of portable equipment in future studies might aid in recruitment of a larger sample, sufficient to detect a greater effect that might occur in female athletes. A greater number of interested participants might also allow the ability to screen shoulder mobility more selectively to allow only those with decreased ROM to be included.

This randomized controlled experiment found that an upper body osteopathic treatment intervention did not improve the outcome of jump reach in female overhead sports players. However, the potential benefits of osteopathy for female athletes can still be acknowledged through the positive impact the intervention had on increasing standing reach height. To determine if a greater effect on vertical jump and reach in female athletes exists, further studies of using a similar design with some improvements in recording of outcomes may be carried out using greater sample sizes, higher competitive levels of athletes and females with more restricted shoulder ROM.

## Practical Applications

Coaches involved in overhead sports such as basketball, netball and volleyball should consider the acute effects osteopathic manual therapy techniques could have on the overall performance of their athletes. Although this study does not show evidence that performing the procedures prior to games can improve vertical jump reach in women, a sister study has shown them to be effective in elite male basketball players. There is data from previous research that may support the efficacy of these procedures on joint ROM in women with restricted shoulder motion, possibly facilitating injury prevention. The improvements may be more beneficial in athletes with greater shoulder restrictions. The incorporation of multiple manual therapy treatment applications a few days prior to game day is another approach coaches might take. Further research is needed to determine whether multiple sessions elicit greater effects on shoulder ROM, and the duration of these effects following treatment.

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# Section 3

# ‘Appendices’

## Appendix A

## Participant Information Sheet

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# Effects of a short term osteopathic intervention package to the upper or lower extremities on the vertical jump and reach in healthy basketball players: A comparative study.

**About This Research**

You are invited to take part in a research project investigating the immediate effects of two osteopathic intervention packages. Osteopathy is a form of manual therapy which considers the interconnected function of the whole body, when applying treatment in order to decrease pain and dysfunction.

The techniques chosen for inclusion in this study are soft tissue massage (ST), muscle energy technique (MET) and high velocity low amplitude (HVLA) thrusts. MET and HVLA involve the researcher moving the patient around until they feel as though there is no more slack within the tissues. To perform an MET, the participant will then try to re-centre their body while the researcher restricts the movement. An HVLA will involve a high-speed compressive movement, which may result in a clicking noise occurring. When applying these techniques, the researcher will take you through movements and put you into different positions in order to decrease dysfunction within the tissues.

The researcher will explain the processes every step of the way and will aim to ensure your comfort through the entire treatment. The techniques will be applied to the upper and lower body. This research will undertaken by Jonathan Hall and Thalia Green (Unitec, Master of Osteopathy students) and supervised by Catherine Bacon (Unitec, Research Supervisor).

This study has the potential to benefit the osteopathic profession and support the techniques that are commonly used.

**Who May Participate in this Study?**

For this study, we are looking for participants between the ages of 18-37 who are part of a sports team playing at a semi-professional competitive level or greater, with a reduced overhead arm range of motion.

Unfortunately, you will not be eligible for this study if you:
- have a previous history of shoulder dislocation or surgery.
- suffer from current upper or lower limb injuries that may hinder your performance.
- are on any medication that may affect the musculoskeletal system, e.g. aspirin.
- have received any form of manual therapy in the last 6 weeks.

If you have any questions in regards to your eligibility, do not hesitate to contact the principal researchers.

**What will happen in this research?**
For this project, you will be asked to attend two days at the Auckland University of Technology Millennium Institute of Sport for data collection.

Each day you will be asked to complete the following:
- A 5 minute warm up consisting of dynamic stretches to the upper and lower body
- Pre-test jump height measurements will be taken
- Osteopathic intervention will be given, focusing on either the upper body or lower body. The opposite area will be worked on the following week
- Jump height will then be measured again

One of the investigators or research assistants will provide instructions for the warm up. Jonathan Hall or Thalia Green will carry out the osteopathic intervention.

**How long does the study go on for?**
This study will be carried out on two separate days, one week apart. You will be asked to attend both days. Each session will take approximately 30-45 minutes. You will be asked to stay for the entire duration.

**Are There Any Discomforts/Risks From Taking Part?**
This study does not present with any obvious risks. If you feel discomfort at any stage of the study, it is important to let the researchers know.

**We treat your personal information confidentially**
All personal information you provide will be treated as confidential and no material that could personally identify you will be used in any reports in this project.

Video footage of you will be required for aspects of this study. Consent for the use of the footage will be obtained on the consent form provided. If you do not feel comfortable about being videoed, you do not have to sign the consent form.

**Do I have to participate in this study?**

Please note that participation in the study is voluntary and that you are not obligated to consent to providing your data for research purposes.

You have the right to withdraw from this study at any stage, up to one week following the end of data collection, for any reason

**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:

Catherine Bacon (Supervisor)
Tel: 815 4321 ext. 7709 (message only)
Email: c.j.bacon@unitec.ac.nz

Jonathan Hall (Research Student)
Tel: 0212662825
Email: jonathan.hall15@gmail.com

Thalia Green (Research Student)
Tel: 0212035031
Email: thaliacgreen@gmail.com

# Appendix B

# Participant Consent Form

## Participant Consent Form

**Research Project Title:** Effects of a short term osteopathic intervention package on the vertical jump and reach height in healthy basketball players: A cross-over design

**I have had the research project explained to me and I have read and understand the information sheet given to me.**

I understand that I don't have to be part of this research project should I chose not to participate and may withdraw up to one week following data collection with no penalty.

I understand that everything I say is confidential and none of the information I give will identify me and that the only persons who will know what I have said will be the researchers and their supervisor. I also understand that all the information that I give will be stored securely on a computer at Unitec for a period of 5 years.

I understand that components of the study will be video recorded.

I understand and consent to all of the outlined techniques and interventions of this study.

I understand that I can see the finished research document.

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

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

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

*Project Researcher: ……………………………. Date: ……………………………*

**UREC REGISTRATION NUMBER: (2014-1093)**

**This study has been approved by the UNITEC Research Ethics Committee from (01/12/2014) to (01/12/2015). If you have any complaints or reservations about the ethical conduct of this research, you may contact the Committee through the UREC Secretary (ph: 09 815-4321 ext 8551). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.**

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**Full name of author:** THALIA CALANTHA GREEN

**Full title of thesis/dissertation/research project:** EFFECTS OF A SHORT TERM OSTEOPATHIC INTERVENTION ON VERTICAL JUMP AND REACH HEIGHT IN FEMALE RECREATIONAL OVERHEAD ATHLETES: A CROSSOVER DESIGN

**Department of** HEALTHCARE PRACTICE PATHWAYS GROUP

**Degree:** MASTER OF OSTEOPATHY **Year of presentation** 2016

Principal Supervisor: Dr Catherine Bacon Associate Supervisor: Frank Bourgeois (AUT)

## EITHER:

(1) I agree to my thesis/dissertation/research project being lodged in the Unitec Library (including being available for inter-library loan), provided that due acknowledgement of its use is made. I consent to copies being made in accordance with the Copyright Act 1994.

**and**

I agree that a digital copy may be kept by the Library and uploaded to the institutional repository and be viewable world wide.

## OR:

(2) I wish to apply for my thesis/dissertation/research project to be embargoed for a limited period as per Academic Policy 12 Conduct of Student Research, Guideline 12/8.

Reason for embargo: ..........

Supervisor Approval: ..........

Dean, Research Approval: ..........

Embargo Time Period: ..........

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**Signature of author:** ..........

**Date:** 2/8/16