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The Role of Joint Manipulation and MET in the Treatment of Lateral Ankle Sprain and Chronic Ankle Instability

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Lateral ankle sprains are common injuries which are often followed by sequelae such as chronic ankle instability, which is associated with adverse outcomes such as pain, increased risk of reinjury, osteoarthritis and significant lost time at work.

This thesis reviewed the role of joint manipulation and MET, commonly utilized treatment techniques in Osteopathy and other manual therapy professions, in the treatment of lateral ankle sprain and chronic ankle instability. 12 studies with a total of 482 subject were included.

Joint manipulation was found to be an efficacious intervention with regards to pain reduction, improved range of motion, and various functional outcomes. The effects of MET on lateral ankle sprains and chronic ankle instability were found to have been insufficiently studied and further research was recommended.

Keywords	Ankle inversion sprain, AIS, Lateral ankle sprain, LAS, Muscle energy technique, MET, joint manipulation, HVT, HVLA, chronic ankle instability, CAI, Osteopathy

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1 Abbreviations

Table 1. List of abbreviations

Abbreviation	Meaning
AIS	Ankle Inversion Sprain
ATFL	Anterior Talofibular Ligament
CAI	Chronic Ankle Instability
CFL	Calcaneofibular Ligament
FAI	Functional Ankle Instability
HVLA/HVLT/HVT	High Velocity Low Amplitude Thrust technique
LAS	Lateral Ankle Sprain
MAI	Mechanical Ankle Instability
MET	Muscle Energy Technique
OA	Osteoarthritis
PTFL	Posterior Talofibular Ligament
RICE	Rest, Ice, Compression, Elevation

2 Introduction

Ankle sprains, of which lateral ankle sprains are most common (McCriskin et al, 2015), are estimated to affect 1 in 10000 people every day (Hershkovich et al, 2015). Those who suffer ankle sprains run 70% risk of suffering sequelae (Gogate et al, 2021), including chronic ankle instability (CAI), which 40% develop within a year of the initial injury (Delahunt et al, 2018). While exercise can be successful at preventing and treating CAI (Doherty et al, 2017), it is nevertheless a common problem which can very persistent, and comes with both costs for the individual sufferer, as well as societal costs (McCriskin et al, 2015).

Consequences of CAI include reduced range of motion (ROM), reduced neuromuscular function, and pain (Alghadir et al, 2020). Muscle Energy Technique (MET) and joint manipulation techniques are widely used by Osteopaths and other manual therapy professions, and proposed benefits include improved ROM, improved neuromuscular function and hypoalgesia (Shin et al, 2020; Thomas et al, 2019; Kumari et al, 2016).

There exists an intersection between the symptoms of CAI and the proposed benefits of these techniques.

The objective of this review is to investigate that intersection.

3 Background

3.1 Lateral ankle sprain injury

3.1.1 Classification of severity and type of ankle sprain injuries

When classifying the severity of ankle ligament injuries, three grades are commonly used, I-III, where grade III is the most severe. A mild sprain is represented by grade I, which entails stretching of one or more ligaments with, at most, microscopic tearing. There may be minor swelling, and walking might cause some minor pain and discomfort. A moderate sprain, grade II, entails an incomplete tear of one or more ligaments, swelling, bruising, pain while walking or bearing weight, general loss of function, and increased joint laxity, may be mild to moderate. Grade III sprains are severe and entail complete ligament rupture(s). Severe pain, gross swelling, bruising, significant joint laxity, inability to bear any weight with the affected foot, and general loss of function are the usual symptoms (Vuurberg et al, 2018).

When referring to ankle sprains, you refer to either mechanism or location of the injury. Ankle inversion sprain (AIS) refers to a sprain of the ankle where the mechanism is excessive inversion of the ankle. If the lateral ligament complex of the ankle is damaged, it is called a lateral ankle sprain (LAS). The main types of ankle sprain injury refer to the location of the damage - these are “high”, “medial” and “lateral”. High sprains can also be referred to as syndesmotic ankle sprains, and medial sprains can also be called deltoid ankle sprains. This review will only deal with lateral ankle sprains (Halabchi & Hassabi, 2020).

3.1.2 Anatomy of the lateral ankle and mechanism of injury

The three main ligaments in the later ankle complex are the anterior talofibular ligament (ATFL), the calcaneofibular ligament (CFL) and the posterior talofibular ligament (PFTL).

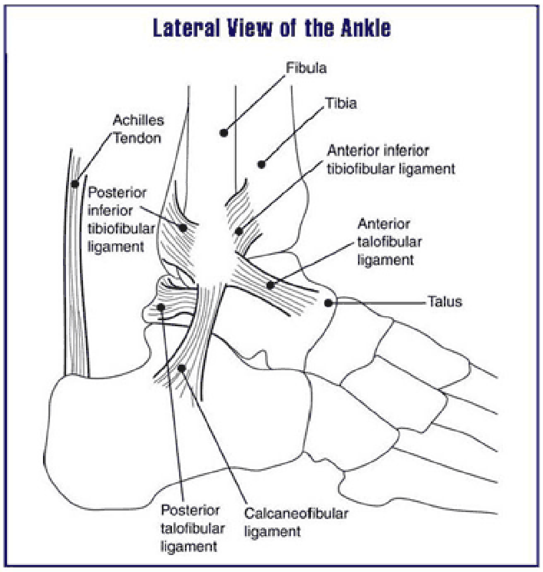

Figure 1. Anatomy of the lateral ligament complex of the ankle (Wikimedia Commons, 2006)

The structure most often damaged in ankle sprains is the ATFL. In two-thirds or more of all ankle sprains it is the first and only ligament to be damaged (Van den Bekerom et al, 2013; Hubbard & Wikstrom, 2010; Fong et al, 2009; Hertel 2002). This is because the most common mechanism of trauma is inversion of the foot in a plantar-flexed position, in which the ATFL is under tension (Van den Bekerom et al, 2013; Hubbard & Wikstrom, 2010). There is a greater moment arm and torque on the subtalar joint when the foot is plantarflexed during initial contact (Fong et al, 2009). The ATFL is also the weakest of the main lateral ankle ligaments by a large margin and can handle the lowest ultimate load (Fong et al, 2009). The medial aspect of the ankle mortise is also relatively short, which puts the ATFL at particular risk (Collins et al, 2004). After an LAS, presence of a hematoma increases the likelihood that a rupture of the ATFL has occurred (Vuurberg et al, 2018). A patient presenting with pain, swelling, bruising and significant joint laxity is almost certain to have suffered a ligament rupture (Halabchi & Hassabi, 2020)

The second most often damaged ligament in the ankle complex is the CFL, followed by the PFTL (Hubbard and Wikstrom, 2010; Hertel, 2002). The CFL is most often injured following an injury to the ATFL, and the reason for this is that when the ATFL is ruptured, the internal rotation of the rearfoot increases, which in turn stresses the other ligaments, as well as joint capsule. Furthermore, injury to the PTFL is only likely when the sprain is very severe and there may also be significant damage to structures other than the ligaments, such as bone and cartilage (Hertel, 2002).

Foot positioning during touch down is an important factor in the aetiology of ankle sprains (Fong et al, 2009). LAS most often occurs when there is excessive inversion of the foot (Van den Bekerom et al, 2013), particularly when the lower leg is externally rotated shortly after rear foot touch down. When this occurs, the ATFL is most exposed to injury when the foot touches down while plantar flexed (Fong et al, 2009; Hertel, 2002), whereas the CFL is more exposed to injury when the foot touches down while dorsiflexed (Fong et al, 2009).

3.2 Chronic ankle instability and its consequences

Lateral ankle sprains left untreated can develop into chronic ankle instability (CAI) and osteoarthritis (OA) (Van den Bekerom et al, 2013), between which there is a significant link; 68-78% of CAI patients develop ankle OA (Wikstrom et al, 2013). A quarter of patients with CAI present clinical signs of anterior impingement of the ankle (Vuurberg et al, 2018). In summary, ankle sprains, among which LAS are the most common, are likely to lead to CAI. CAI can cause suffering, reduced physical ability or even disability and degenerative disease, as well as costs. In up to 60% of *patients* (which implies they have received some treatment) with CAI, significant time lost at work has been reported (McCriskin et al, 2015).

Chronic Ankle instability can be subdivided into mechanical ankle instability (MAI) and functional ankle instability (FAI). While they often overlap, they are not necessarily concurrent (Algahdir et al, 2020; McCriskin et al, 2015).

3.2.1 Mechanical ankle instability

MAI is described as anatomical changes occurring after an initial ankle sprain, identifiable though physical or instrumental examination, which cause insufficiencies that compromise the stability of the joint. These include pathologic joint laxity, various tissue changes including synovial and degenerative ones, and impaired joint mechanics (Algahadir et al, 2020; McCriskin et al, 2015; Hertel, 2002). Impaired proprioceptive signalling from ligamentous structures could then lead to FAI (Alghadir et al, 2020). If mechanical instability is not addressed after an LAS, the ankle can be further compromised through additional tissue adaptations and changes in joint alignment, as well as increased functional deficits (Hubbard & Wikstrom, 2010).

3.2.2 Functional ankle instability

Functional ankle instability is described as deficits in the neuromuscular system that stabilizes the ankle (Hertel, 2002). This includes quantifiable shortfalls in the following: kinesthesia and proprioception (Hertel, 2002; Xue et al, 2020; Alghadir et al, 2020), particularly in inversion and plantarflexion (Xue et al, 2020); nerve conduction velocity, neuromuscular recruitment patterns and response times, particularly in the peroneals (Pietrosimone & Gribble, 2012; Hertel, 2002); postural control and balance (Hertel, 2002; Hubbard & Wikstrom, 2010), as well as strength (Hertel, 2002).

3.3 Incidence of lateral ankle sprains and chronic ankle instability

The ankle joint complex is one of the most often injured sites in general sports. 10-30% of all sports related injuries are incurred to ankles (Loudon et al, 2014; Fong et al, 2007). In many sports, sprain injury to the ankle is the most common type of acute trauma, and in Sweden, ankles are the third most injured site in sports (Fong et al, 2007).

A significant percentage (7-10%) of hospital emergency department admissions are caused by ankle sprains, and while most are incurred during physical exercise, about half are not (Van den Bekerom et al, 2014). Total incidence worldwide has been estimated to about 1 per 10000 individuals per day (Postle et al, 2012; Hershkovich et al, 2015). For Sweden, with a population of a little under 10,4 million in 2020 (Sveriges befolkning, 2021), this would tally to an average of over 1000 ankle sprains per day.

Of all ankle sprains, approximately 85% affect the lateral ligament complex (McCriskin et al, 2015). Half or more of those who suffer LAS do not seek or receive treatment (Hubbard & Wikstrom, 2010; Wikstrom et al, 2013; Vuurberg et al, 2018), and therefore the true incidence may be higher (Wikstrom et al, 2013). This may be because it is falsely considered a trivial injury by many or even most (Hubbard & Wikstrom, 2010). Furthermore, in the first two weeks after injury, pain rapidly decreases, which may add to the impression that it is a trivial injury (van Rijn, 2008). In the US, there are indications that as many as two-thirds of all ankle injuries are not treated (Pietrosimone and Gribble, 2012).

The risk of an LAS turning into CAI is contingent on the severity of the incurred sprain (Vuurberg et al, 2018). Approximately 40% suffer from it within a year of the injury (Delahunt et al, 2018). 70% or more of all who incur an LAS will have residual symptoms of some sort at some point after the initial injury (Gogate et al, 2021; DeMers et al, 2017; Hertel, 2002; Hertel 2000).

3.4 Risk factors for lateral ankle sprain and chronic ankle instability

To understand both the causes and treatment of LAS and CAI, associated risk factors must be considered. They may or may not be causative, but correlations nevertheless exist. Ankle sprain risk factors can be classified as intrinsic and extrinsic factors. The former arises within the body, while latter originates from outside of the body (Fong et al, 2009; Hershkovich et al, 2015; Vuurberg et al, 2018).

3.4.1 Intrinsic risk factors

Numerous intrinsic factors have been linked to an increased risk of sustaining an LAS. Examples of intrinsic risk factors are shown in Table 2 and are listed in no order of significance. Note that many of the listed risk factors are properties of CAI.

Table 2. Intrinsic risk factors

Factor	Variable associated with risk
Age	Ages associated with competitive sports; late middle age and older
Sex	Female
Height	Tall
Weight	Overweight
Previous Injuries	Ankle sprain, particularly if inadequately rehabilitated
Dorsiflexion ROM	Deficient
Postural stability and control	Deficient
Proprioception in ankle complex	Deficient
Foot/ankle alignment	Excessive supination
Strength	Deficient in dorsiflexion and hip abduction
Eversion to inversion strength ratio	Deficient
Dorsiflexion to plantarflexion strength ratio	Deficient
Limb dominance	Excessive
Peroneal reaction time	Deficient
Aerobic fitness	Deficient

(Vuurberg et al, 2018; Powers et al, 2017; McCriskin et al, 2015; Hershkovich et al, 2015; Fong et al, 2009; Friel et al, 2006)

Some are widely stated to affect the risk of LAS. For example, most of the literature lists previous ankle sprain as the most correlated risk factor (McCriskin et al, 2015; Van den Bekerom et al, 2013; Hubbard & Wikstrom, 2010; McKay et al, 2001).

Other factors are still debated. An example of this is whether foot type/morphology affects the risk of sustaining an LAS. There is some support for this being the case (McCriskin et al, 2015; Hershkovich et al, 2015), but there is not universal agreement (Fong et al, 2009).

Females are at higher risk of sustaining LAS than males (McCriskin et al, 2015). Risk factors more specific to women include hypermobility, poor proprioception, and impaired postural control (Fong et al, 2009). Risk factors more specific to males are neuromuscular imbalances, low balance ability and low fitness levels in general (Fong et al, 2009). Weight, specifically overweight, is correlated with both LAS and CAI (Vuurberg et al, 2018; McCriskin et al, 2015; Hershkovich et al, 2015; Fong et al, 2009). In both males and females, height was strongly associated with CAI, but the association was stronger in males than females (Hershkovich et al, 2015).

Both high medial plantar pressure during running and a lateralized point of contact (supinated foot) during the stance phase have been reported as increasing risk for sustaining an LAS (Vuurberg et al, 2018; Fong et al, 2009).

3.4.2 Extrinsic risk factors

Extrinsic risk factors for sustaining an LAS are related to the type of activity being performed, the intensity at which it is performed, what the environment is like, and various other factors which are external to the individual (Vuurberg et al, 2018; McCriskin et al, 2015). Sports, particularly at more elite levels which tend to both have a higher power output and less time for recouperation, increases the risk of LAS. Competitions are more correlated with LAS than training or exercise (McCriskin et al, 2015). Sports with a particularly high incidence of ankle injury have been reported to be football, basketball, volleyball, as well as running and dancing (Van den Bekerom, 2013; Postle et al, 2012). Common to most of these are rapid directional changes. In team sports, these can also take to form of being tackled, and furthermore, there is also the risk of being tripped. Uneven, rocky, or slippery terrain increases risk.

Footwear with poor suitability for task increase risk of an LAS as well (McCriskin et al, 2015). Variables include for example the width, lateral stability and rigidity of the sole, ankle bracing, foot compression, rigidity of the shoe body, the fit of the shoe on the foot, and ability to provide traction. Different use cases require different combinations of these. For example, when running on wet grass, good grip is desirable to avoid slipping, particularly when changing directions, which entails a large angular momentum. Such a use case might also require shoes with passive restraints to ankle inversion, due the increased shearing forces on the ankle when executing a rapid turn while subject to good traction. An almost inverse case would be dancing, during which less grip is usually desired, depending upon specific dance. In general, dance shoes are slippery to allow for, among other things, slides, spins and turns without getting "stuck" to the floor, which would increase the risk of ankle or knee injury, as well as falls. Often, the soles of specialized dance shoes have different areas with differing amounts of traction.

3.5 Treatment of ankle sprains and prevention of chronic ankle instability

While sufficiently severe sprains might require reconstructive surgery, conservative treatment is preferred unless: (1) fractures are present; (2) the is an unstable high sprain; (3) joint kinematics are severely altered; (4) conservative treatment is ineffectual. In most cases, conservative treatment is as effective as surgery, and runs less risk of leading to osteoarthritis and other complications associated with surgery such as infection and iatrogenic nerve damage (Halabchi & Hassabi, 2020).

Many factors must be addressed when treating ankle sprains, and any rehabilitation program must be thoroughly planned to promote an optimal healing process. It should focus on correcting mechanical or arthokinematic changes, incorporating proprioceptive training, balance training, strength training, and improving neuromuscular control (Alghadir et al, 2020). Failure to do this may increase the risk of CAI and other long-term sequelae (Van den Bekerom et al, 2013).

While there is not universal agreement on the efficacy of manual therapies in any of the stages of healing (Doherty et al, 2017), support exists (Halabchi & Hassabi, 2020), and the utility of various manual therapies will be examined later in this review.

Professions that might be involved in the treatment and management of lateral ankle sprains include medical doctors, physiotherapists, Osteopaths, other manual therapists, and even personal trainers and sports coaches, depending upon setting. As will be shown later in this review, LAS and CAI often require multi-modal approaches.

Treatment of ligamentous injuries should consider the stages of ligament healing (Van den Bekerom et al, 2013). These stages are referred to as (1) The inflammatory (acute) phase, (2) The proliferation (subacute) phase, and (3) The remodelling and maturation phase.

3.5.1 The inflammatory / acute phase

The first step in managing an LAS is creating the proper conditions for the ligamentous healing process. The primary objective is to control pain, inflammation, swelling, and prevent movements that will increase the laxity of the lateral ligaments or injure them further (Van den Bekerom et al, 2013).

Rest, ice, compression, and elevation (RICE) can be useful during the first 4-5 days of a sufficiently severe sprain (Van den Bekerom et al, 2013), but the decision to use the RICE approach should be based upon individual circumstances, and a grade I sprain may not need this approach. (Doherty et al, 2017). For grade III sprains, some immobilization may be required, particularly if avulsion fractures are suspected. Otherwise, immobilization should be kept as brief as possible, and if deemed reasonable, only semi-rigid restraints should be used (McCriskin et al, 2015).

In general, as little immobilization as possible should be used, and mobilization should begin as soon as is tolerable to the patient. This minimizes the risk of CAI and other sequelae (McCriskin et al, 2015). Movement should be introduced to the affected ankle, and this can be aided by for example cold-packs to manage pain (Ortega-Avila et al, 2020). Taping or non-rigid bracing can be useful to get and keep patients moving early on and to prevent further damage. RICE can be utilized briefly to manage swelling and pain (McCriskin et al, 2015). As the pain and inflammation decrease, the individual can transition into a more functional rehabilitation, and the earlier this is done, the better the outcome (McCriskin et al, 2015).

Depending on the severity of the sprain, the inflammatory phase can last up to 6 weeks (Van den Bekerom et al, 2013).

3.5.2 The proliferation / subacute phase

When the inflammatory phase has ended and any swelling is gone, there is the proliferation phase. Significant physiological changes occur, such as the formation of new collagen fibres and fibroblast proliferation (Van den Bekerom et al, 2013). Controlling and protecting the talocrural joint's movement, especially against excessive inversion, is vital during this phase. Failure to do so may lead to excess formation of weaker type III collagen, which can the increase risk of permanent lengthening of healing ligaments (Van den Bekerom et al, 2013). Controlled stress (loading) of the lateral ligaments should still be allowed to occur, since this will promote correct orientation of collagen fibres, and taping during this phase has shown good results in moderating load and preventing excess inversion (Van den Bekerom et al, 2013). The effects of any prior immobilization must also be tackled. These include atrophy and reduced proprioception (Halabchi & Hassabi, 2020; Van den Bekerom et al, 2013). Exercises for strength and mobility should be provided, but restoring neuromuscular function and balance is imperative (Halabchi & Hassabi, 2020; McCriskin et al, 2015; Van den Bekerom et al, 2013).

The proliferation phase lasts from when the inflammatory phase ends and then up to about 6 weeks (Van den Bekerom et al, 2013).

3.5.3 The remodelling and maturation phase

During the remodelling phase, disorganized fibres (scar tissue) are realigned and strengthened, and type III collagen fibres are replaced by stronger type I fibres (Lorenz & Longaker, 2008). Treatment should focus on promoting that process and on removing any lingering deficits in strength, balance, proprioception, as well as reduced ROM. Some protective taping can be used when there is increased risk of reinjury but stretching and loading must still be permitted to occur to facilitate final healing (McCriskin et al, 2015; Van den Bekerom et al, 2013). Failure to facilitate final healing and removing lingering deficits increases risk of CAI (Van den Bekerom et al, 2013).

The maturation phase lasts up to 9 months after the proliferation phase ends (Van den Bekerom et al, 2013)

3.5.4 Success rates of conservative treatment of LAS

Receiving initial treatment and rehabilitation after an LAS decreases the risk of sequelae, but an estimated 40% still end up with CAI, which indicates gaps in the knowledge of what makes treatment of LAS successful or not (Delahunt et al, 2018; Vuurberg et al, 2018; Hershkovich et al, 2015). More rigorous research is needed to find out what the most effective interventions are at different stages of the injury (Ortega-Avila et al, 2020).

3.6 Treatment of chronic ankle instability

Treating CAI with exercise is probably the most supported intervention, and it significantly decreases risk of reinjury. Neuromuscular exercises that increase proprioception are particularly supported (Doherty et al, 2017). Bracing is also supported as a means of decreasing risk of reinjury to unstable ankles (Doherty et al, 2017). Attention should be paid to if the instability is primarily mechanical or functional, as these have somewhat different properties and may require different approaches.

For severe cases of mechanical instability that are unresponsive to conservative treatments, there are various surgical alternatives, such as the modified Brostrom-Evans-Gould technique. It involves surgical shortening of elongated ligaments and using harvested retinacula and tendons to surgically brace the ankle (Ng & De, 2007).

3.7 Muscle energy technique and high velocity low amplitude thrust technique

MET and HVLA are commonly used for treating and managing various dysfunctions of the musculoskeletal system by many manual therapist professions. These include Osteopathy, from which MET derives (Chaitow, 2013). While the mechanism of action of the two treatment techniques are unclear, there are various levels of support for their proposed effects. Examples are shown in Table 3.

Table 3. Some proposed effects of MET and HVLA with references

Effect	MET	HVLA
Hypoalgesia	Sturion et al, 2020; Thomas et al, 2019; Faqih et al, 2019; Nambi et al., 2013; Fryer, 2011	Sturion et al, 2020; Shin et al, 2020; Vuurberg et al, 2018; Loudon et al, 2014; Weerasekara et al, 2018; Martinez-Segura et al, 2006
Increased ROM and/or increased extensibility of muscles	Thomas et al, 2019; Faqih et al, 2019; Baidya et al, 2018; Burns & Wells, 2006; Lenehan et al, 2003	Shin et al, 2020; Vuurberg et al, 2018, Smith & Fryer, 2008; Loudon et al, 2014; Eisenhart et al, 2003; Weerasekara et al, 2018; Martinez-Segura et al, 2006; Nogueira de Almeida et al, 2010; Hubbard et al, 2010
Improved neuromuscular function	Kumari et al, 2016; Fryer, 2011; Joseph, 2010	Shin et al, 2020
Improved fluid mechanics	Fryer, 2011; Joseph, 2010	Eisenhart et al, 2003;

Both MET and HVLA are classified as direct techniques, which means they are directed into restrictive barriers. Furthermore, MET is also an active technique, which means it requires active participation from the patient. HVLA is considered a passive technique, which means that the patient is passive.

3.8 Osteopathic treatment of lateral ankle sprains and chronic ankle instability

Osteopaths employ a wide variety of techniques and approaches. The panoply includes, but is not limited to: (1) soft tissue techniques (Burke et al, 2013); (2) joint mobilization/articulation without impulse (Burke et al, 2013); (3) High-velocity-low-amplitude-thrust joint manipulation (HVLA/HVLAT/HVT)(Burke et al, 2013); (4) Muscle energy technique (MET) (Burke et al, 2013); (5) functional techniques (Burke et al, 2013); (5) Exercise (Burke et al, 2013); (6) Education (Burke et al, 2013).

The degree to which different techniques and approaches are used seem to vary between countries (Burke et al, 2013). In Australia more than half of all treatment approaches involved soft-tissue techniques, articulation techniques and MET, which might say something about their efficacy (Burke et al, 2013). In Spain, mobilization, soft-tissue and HVLA were the most used techniques, and only about 9%-12% of treatments involved MET (Alvarez et al, 2018). In the UK, soft-tissue techniques and articulation techniques were most often used (Fawkes et al, 2014). The differences might have something to do with how osteopathic students are taught (Burke et al, 2013).

Osteopathic manipulative treatment of acute ankle sprains, involving soft tissue techniques, fascial techniques, joint manipulation, and lymphatic drainage techniques, has been successfully employed in hospital settings to reduce pain, increase ROM and reduce swelling (Eisenhart et al, 2003).

While there is a lack of available research on Osteopathic approaches to LAS and CAI, and how frequently they are encountered by Osteopaths in clinic, they without doubt do encounter and treat those conditions.

4 Research question and aim

Three main justifications were found for this review: (1) the high incidence of lateral ankle sprains (LAS) and chronic ankle instability (CAI); (2) the overlap of the symptoms of LAS and CAI and the proposed effects of HVLA and MET; (3) the wide adoption of said techniques among manual therapists in general and Osteopaths in particular.

As previously stated, symptoms of LAS and CAI, which often overlap, include: (1) pain and discomfort; (2) decreased ROM; (3) reduced neuromuscular function; (4) impaired functional outcomes.

This is mirrored by the proposed effects of MET and HVLA, which both include: (1) hypoalgesia; (2) improved ROM; (3) improved neuromuscular function.

The protocols around exercise and rehabilitation for LAS and CAI are well established, but the use of manual therapies such as MET and HVLA for these conditions required more clarity.

The primary aim of this review was therefore to answer what the role of HVLA and MET is in the treatment and management of LAS and CAI.

A subsidiary aim was to discuss the role of Osteopathy in the treatment of said conditions, given that HVLA and MET are included in the osteopathic repertoire.

5 Method

5.1 Adjusted aims

This study took the form of a literature review. An initial search of two electronic databases, PubMed and ScienceDirect, was performed to determine feasibility. The initial aim was to find, review and collate studies on the utility and efficacy of MET when used to treat ankle inversion sprains (AIS), but a dearth of available research papers and studies on the use of MET on AIS was encountered. The search was broadened to also include joint mobilization and chronic ankle instability.

5.2 Identification of studies

A search strategy was developed using the following terms:

Muscle Energy Technique"; "MET"; Mobilization"; "Manipulation"; "ankle sprain"; "chronic ankle sprain"; "chronic ankle instability"

These were combined and linked with the Boolean operator "AND":

- "Muscle Energy Technique" AND "ankle sprain"; "Muscle Energy Technique" AND "chronic ankle sprain"; "Muscle Energy Technique" AND "chronic ankle instability"

- "MET" AND "ankle sprain"; "MET" AND "chronic ankle sprain"; "MET" AND "chronic ankle instability"

- "Mobilization" AND "ankle sprain"; "Mobilization" AND "chronic ankle sprain"; "Mobilization" AND "chronic ankle instability"

- "Manipulation" AND "ankle sprain"; "Manipulation" AND "chronic ankle sprain"; "Manipulation" AND "chronic ankle instability"

Inclusion and exclusion criteria (shown in Table 4 and 5, respectively) were developed to facilitate the aim of this review.

Table 4. Inclusion criteria

	Inclusion criteria	Reasoning
Language	English	Authors´ shared language
Publication type	Journal article	Ease of search
Article publication year	2006 or later	More recent studies were preferred
Condition	LAS and/or sequelae thereof	LAS is the most common form of ankle injury
Timing	**At least one:** Acute Subacute Chronic*	*Search was broadened to include chronic
Intervention	**At least one:** Muscle energy technique (MET) Joint mobilization* HVLA*	MET and HVLA are common tools of manual therapy. *Search was broadened to include joint manipulation. Joint mobilization included due to overlap in utility and terminological confusion.
Body part	**At least one:** Distal tibiofibular joint Talocrural joint	Target structures should be local to the injury
Outcome measure	**At least one:** Ankle joint ROM Pain levels Inflammation parameters such as swelling Some functional outcome	Background reading showed these were primary applicable outcome measures
Quality	PEDro score of 6 or more	Studies of medium quality or better were preferred.

Table 5. Exclusion criteria

	Exclusion criteria	Reasoning
Language	Articles not in English	See inclusion criteria
Article type	Systemic reviews and meta-analyses	Original results and conclusions were preferred
Article publication year	Earlier than 2006	Older studies may have become obsolete
Condition	Ankle injuries other than lateral ankle sprains and related sequelae	Limited disposable time required limited focus
Intervention type	Invasive intervention or requiring complex tools	Manual therapy is more accessible and less costly than complex or invasive interventions
Quality	<6 on the PEDro scale	See inclusion criteria

A search of two electronic databases, PubMed and ScienceDirect was performed. The search resulted in 1995 articles, and the titles of all studies were reviewed. Following a screening of titles, 25 articles were selected and evaluated for eligibility by screening the abstract content, and then by full article content, according to inclusion and exclusion criteria. Two reviewers completed the full-text screening independently. 13 articles were selected for quality assessment.

5.3 Quality assessment and final inclusion

The quality of 12 articles was evaluated independently by one reviewer (MA) using the PEDro scale (PEDro, 2021), which uses 11 criteria. Satisfying each criterion adds one point. The PEDro scale asses external and internal validity in clinical trial studies, as well as interpretability. Higher scores indicate higher quality in these areas. A score of 6 was deemed the lowest acceptable score for inclusion. One article was excluded for having low score, and 12 articles were selected for further analysis.

See Appendix 1 for a list of PEDro criteria and assessment results table.

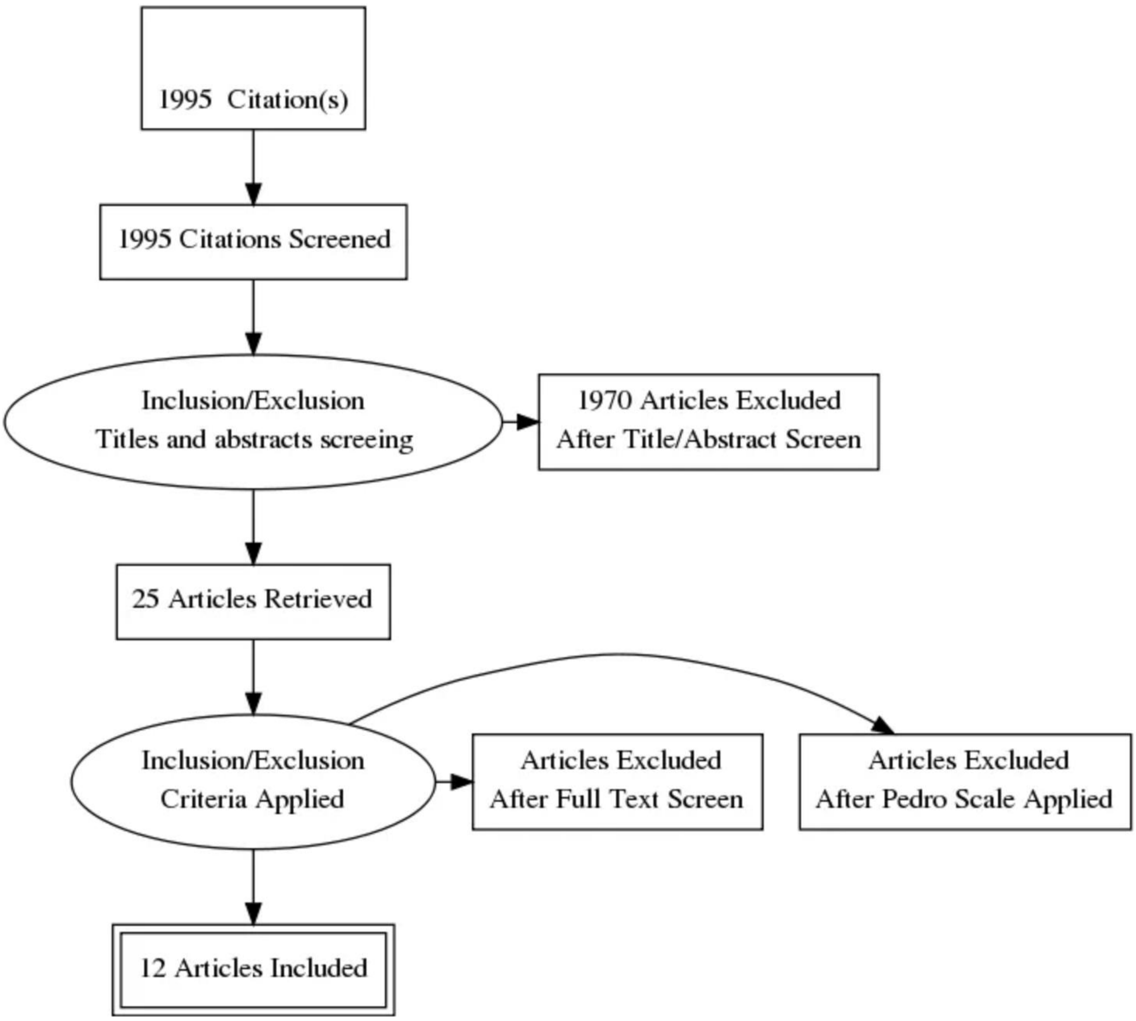

Figure 2. Flow diagram of article inclusion (PRISMA Diagram Generator, 2021)

5.4 Data extraction and analysis

12 articles were reviewed in-depth. Key information such as study design, outcome measures and results were extracted and entered in Table 6. Two reviewers cross-checked independently. The results were then analysed.

6 Results

6.1 Overview

Key information for each selected article, such as study design, number of subjects, variables studied and outcomes, are shown in Table 6.

Table 6. Overview of the selected studies

Title	Study design	Subjects	Treatment	Variables studied + Results
The effectiveness of mobilization with movement on pain, balance and function following acute and sub-acute inversion ankle sprain (Gogate et al, 2021)	Randomized placebo-controlled trial Experimental group MWM (distal tibiofibular joint) = 16 Placebo group = 16 6 treatments over 2 weeks Subjects: acute and sub-acute grade I and II inversion ankle sprain	n = 32 19m 13f 18+	X= 6 2w period	**Variables:** Pain intensity (NRS); Foot and Ankle Disability index (FADI) score; Functional dorsiflexion ROM; Y balance test YBT; Pressure pain threshold (PPT) **Statistically significant changes after 2 weeks:** **NRS point decreased** (pre:5.9 vs. post: 2.8), **FADI score increased** (pre: 65.5 vs. post: 79.8) **Dorsiflexion increased** (pre: 26.7° vs. post: 36.4°) Y-test (pre: 25.9 vs. post: 27.4) **PPT peripheral** (pre: 25.9 vs. post: 27.4), **PPT central** (pre: 31.7 vs. post: 35.2) **YBT-Forward increased** (pre: 57.6 vs. post: 63.4), **YBT-Posterolateral increased** (pre: 57.8 vs. post: 76.4), **YBT-Posteromedial increased** (pre: 60.6 vs. post: 74.7)

Manipulative Therapy Plus Ankle Therapeutic Exercises for Adolescent Baseball Players with Chronic Ankle Instability (Shin et al, 2020)	Single blind randomized controlled trial Intervention group – HVLA + exercise (talocrural joint) = 16 Control group – exercise only = 15 8 treatments over 4 weeks Subjects: CAI	n = 31 All males 12-16yo	x = 8 4w period	**Variables:** Ankle status; Pain intensity; Pain pressure threshold; Ankle ROM; Balance ability **Statistically significant changes for Intervention group:** **AOFAS Total score** (pre:65.06 vs. post:83.88, p = 0.002), **AOFAS Pain score** (pre:27.5 vs post:34.38, p<0.001), **VAS-resting pain decreased** (pre:11.4 mm vs. post:1.25 mm, p< 0.001), **VAS-movement pain decreased** (pre:40.65 mm vs. post:7.9 mm, p< 0.001) **Dorsiflexion ROM increased** (pre:34.26° vs. post:41.02°, p = 0.006), **Eversion ROM increased** (pre:23.85° vs. post:28.12°, p = 0.026) **Balance path length** (pre:51.79 cm vs. post:40.40 cm, p = 0.006), **Balance velocity** (pre:5.18 cm/s vs. post:4.05 cm/s, p = 0.006)
Efficacy of muscle energy technique and contract relax with mulligan's mobilization with movement technique in subacute ankle sprain (Baidya et al, 2018)	Randomized clinical trial MET & Mulligans MWM = 20 Contract Release & Mulligans MWM = 20 12 treatments over 4 weeks Subjects: subacute	n = 40 24m 16f 16-30yo	x = 12 4w period	**Variables:** Pain (NPRS scale); Gait variables; Ankle ROM **Statistically significant changes for MET groups:** **MET-NPRS decreased** (pre:4.8 vs. post: 0.25 p < .001), **MET-Dorsiflexion ROM increased** (pre:9° vs. post:16°, p < .001), **MET-Plantarflexion ROM increased** (pre: 40.25° vs. post:45.5°, p < .001), **MET-Inversion ROM Increased** (pre:14.25° vs. post: 22°, p < .001), **MET-Eversion ROM Increased** (pre: 12°vs. post:15.25 ° p < .001) **Significant improvement** (p<0.05) in swing duration, stride duration, and gait cycle length for MET group. **Significant improvement** (p<0.05) in step duration, double stance duration, step length, sole area for both treatment group.

Effects of Anteroposterior Talus Mobilization on Range of Motion, Pain, and Functional Capacity in Participants with Subacute and Chronic Ankle Injuries: **(Silva et al, 2017)**	Parallel design controlled trial Experimental group (Grade III Maitland) = 19 Sham group = 19 Subjects: subacute and chronic traumatic ankle injury subjects	n = 38 16m 22f x̄40,8yo	x = 6 2w period	**Variables:** Dorsiflexion ROM; VAS Pain (cm); Functional capacity **Results for experimental group (Baseline, 6^{th} session – follow up):** **Dorsiflexion ROM increased** (pre:8.7° - 6^{th}:12.8° - fup:13.2°) **VAS-pain Score** (pre:2.1 - 6^{th}:0.7 – fup:0.3) **FAAM ADL score** increased (pre:59.2 - 6^{th}:79.9 – fup:86.6) **FAAM Sport score increased** (pre:9.8 - 6^{th}:31.3 – fup:45.8)
Predicting Manual Therapy Treatment Success in Patients with Chronic Ankle Instability: Improving Self-Reported Function **(Wikstrom & McKeon, 2017)**	Randomized clinical trial Ankle joint mobilization = 20 Plantar massage = 19 Calf stretch = 20 6 treatments over 2 weeks Subjects: CAI	n = 59 All females	x = 6 2w period	**Variable:** Treatment Success **Results:** Ankle mobilization: 12 of 20 patients (60%) had a successful treatment and averaged a 20.3% improvement in FAAM–S score Plantar massage, 8 of 19 patients (42%) had a successful treatment and averaged a 19.1% increase in FAAM–S score Calf stretching, 9 of 20 patients (45%) had successful treatment and averaged a 20.1% increase in FAAM–S score
The immediate effect of talocrural joint manipulation on functional performance of 15-40 years old athletes with chronic ankle instability **(Kamali et al, 2016)**	Double blind randomized clinical trial TCJM group (talocrural joint) = 20 Sham manipulation group = 20 3 treatments over 3 weeks Subjects: CAI	n = 40 18m 22 f 15-40yo	x = 3 3d period	**Variables:** Single leg hop; Speed tests; Y balance tests **Statistically significant changes for TCJM group:** TCJM significant improvement ($p<0.05$) in all functional tests. **Speed test** (pre:18.98 vs. post:17.22 p <.001) **Hop-test** (pre:157 vs. post:162 p=0,003) **Y-test Anterior** (pre:9342 vs. post:96.76 p=0,009) **Y-test posterolateral** (pre:87.64 vs. post:94.86 p < .001), **Y-test posteromedial** (pre:86.4 vs. post:91.77 p=0.020)

Effect of chiropractic manipulation on vertical jump height in young female athletes with talocrural joint dysfunction (Hedlund et al, 2014)	Single blind randomized clinical pilot trial HVLA manipulation (of talocrural joint) = 11 Sham treatment = 11 3 treatments over 3 weeks	n = 22 All females 16+ yo	x = 3 3w period	**Variable:** Vertical jump height **Results:** Significant mean (SD) improvement in vertical jump height for HVLA = 1.07 (0.24 to 1.90, P = .017) cm. Sham treatment improved their vertical jump height by 0.59 (−1.11 to 2.29) cm but it was not statistically significant
Manipulative therapy and rehabilitation for recurrent ankle sprain with functional instability (Lubbe et al, 2015)	Single blind, parallel-group randomized trial Experimental group (HVLA on mortise, subtalar, and/or tarsal joints Plus exercise) = 15 Control group (exercise only) = 18 6 treatments of 5 weeks Subjects: CAI	n = 30 16m 14f 12-30yo	x = 6 5w period	**Variables:** Pain; Joint motion palpation **Results:** Between-group no significant difference in scores at the same time- point for the FADI (P = .26) Statistically significant differences (p<0.006) in scores at week 5 for VAS and for the frequency of joint restrictions determined by motion palpation
The effect of two mobilization techniques on dorsiflexion in people with chronic ankle instability (Marron-Gomez et al, 2013)	Randomized controlled clinical trial HVLA group (talocrural joint) = 19 MWM group (Weight-bearing mobilization) = 18 Placebo group = 15 Single treatment Subjects: CAI	n = 52 31m 21f 15-36yo	n = 1 Single	**Variables:** Weight-bearing ankle dorsiflexion measured with the weight-bearing lunge **Statistically significant changes for both groups in dorsiflexion ROM** Dorsiflexion ROM increase in both groups compared to placebo group (p<0.001) **HVLA group** (pre:11.13 cm - post:13.4 cm - 10min: 13.9 cm - 24h:13.8cm - 48h:12.9 cm) **MWM group** (pre:9.8 cm - post:11.5 cm - 10min: 11.8 cm - 24h:11.9 cm - 48h:12 cm) **Control group** (pre:8.5 cm - post:8.3 cm - 10min: 8.5 cm - 24h:8.4 cm - 48h:8.3 cm) No differences between treatment groups.

Effects of a Proximal or Distal Tibiofibular Joint Manipulation on Ankle Range of Motion and Functional Outcomes in Individuals With Chronic Ankle Instability (Beazell et al, 2012)	Randomized clinical trial HVLA Proximal tibiofibular manipulation (PTM)= 15 HVLA Distal tibiofibular manipulation (DTM) = 15 Control (CG) - no treatment = 13 4 treatments over 3 weeks Subjects: CAI	n = 43 18-33yo	x = 4 3w period	**Variables:** Ankle dorsiflexion range of motion; Functional outcomes **Results:** No significant change in dorsiflexion between groups across time (p=.82). 1. PTM ROM (pre: 37° vs. post: 42.6°) 2. DTM ROM (pre: 35.2° vs. post: 39°) 3. CG ROM (pre: 37° vs. post:41.5°) Results pooled- statistically significant changes**:** Dorsiflexion increased (pre:36.2° vs. post:41.1°, p<.001): No differences in the Balance Error Scoring System foam, step-down test, and FAAM sports subscale scores.
Immediate effects of a tibiofibular joint manipulation on lower extremity H-reflex measurements in individuals with chronic ankle instability (Grindstaff et al, 2011)	Randomized clinical trial HVLA Proximal tibiofibular manipulation = 15 HVLA Distal tibiofibular manipulation = 15 Control - no treatment = 13 Single treatment Subjects: CAI	n = 43 x̄25,6yo	x = 1 Single	**Variables:** Fibularis longus activation; Soleus activation **Results:** The distal tibiofibular joint manipulation significant increase (P < .05) in soleus H/M ratio at all post-intervention time periods except 20 min post-intervention (P = .48). The proximal tibiofibular joint manipulation and control groups no change in soleus H/M ratios.
Immediate effects of manipulation of the talocrural joint on stabilometry and baropodometry in patients with ankle sprain (Lopez-Rodriguez et al, 2007)	A simple blind, intrapatient, placebo-controlled, and repeated-measures study Intervention group (TC-HVLA & Talus P. glide) Placebo group Single treatment Subjects: acute grade II inversion ankle sprain	n = 52 18-40yo 35m 17f	x = 1 Single	**Variables:** Stabilometric outcomes; Baropodometric outcomes **Results:** The intervention group significant differences **Posterior load** (pre: 17.38% vs. post:16.09% p=0.015) & **Bilateral anterior load** (pre: 64.17% vs. post:66.34% p=0.02) The placebo group showed no difference

6.2 Summary of general characteristics of selected studies

The total number of subjects in the 12 articles selected was 482, 206 females, and 190 males. The number of subjects ranges from 22 to 59, and the age range is 16-45 years. Two studies were all-female and one all-male, but two studies did not specify gender.

Nine studies were RCT, one simple blind, intrapatient, placebo-controlled, and repeated-measures study. One an assessor-blind, parallel-group randomized comparative trial, and one single-blind randomized clinical pilot trial. 10 of the 12 studies had control groups and two had comparative intervention groups (Wikstrom & McKeon, 2017; Baidya et al, 2018).

The treatment duration was from 2 days (Marron-Gomez et al, 2013) to 5 weeks (Lubbe et al, 2015). Three studies conducted a single treatment (Lopez-Rodriguez et al, 2007; Grindstaff et al, 2011; Marron-Gomez et al, 2013), and nine studies were multiple treatment studies.

Eight studies incorporate and evaluated HVLA as a treatment protocol, two studies used HVLA plus exercise (Lubbe et al, 2015; Shin et al, 2020). Five studies manipulated the talocrural joint, two studies proximal and distal tibiofibular joint (Grindstaff et al, 2011; Beazell et al, 2012), and one study mortise, subtalar and/or tarsal (Lubbe et al, 2015). Three studies incorporated joint manipulation to the talocrural joint (Wikstrom & McKeon, 2017; Silva et al, 2017; Gogate et al, 2021), and one study involved MET plus exercise.

6.3 Outcome measures

In this review, nine studies measured functional variables; six studies measured ankle ROM, five studies measured pain variables.

Researchers used a variety of methods to measure outcomes. For functional outcome measures, several questionnaires were employed, as is shown in Table 7.

Table 7. Functional outcome questionnaires

Questionnaire	Description
The Foot and Ankle Ability Measure (FAAM)	The FAAM is a 29-item questionnaire with two sub-scales; 21 questions for **activities of daily living** (ADL) and 8 questions related to **sports activities** that asses how musculoskeletal disorders of the leg, ankle, and foot complex affect functional capacity (Martin, 2005).
The Foot and Ankle Disability Index	The Foot and Ankle Disability Index is a 34-item questionnaire divided into two sub-scales: the **Foot and Ankle Disability Index** with 26 questions (4 pain-related and 22 activity-related questions), and the **Foot and Ankle Disability Index Sport** with 8 questions (Gogate et al, 2021)
American Orthopedic Foot and Ankle Society (AOFAS) score	Three-part assessment of **pain** (40 points), **function** (45 points) (gait abnormality, sagittal motion, ankle stability, and hindfoot motion), and **alignment** of the foot and ankle joints (15 points) in patients with discomfort in foot and ankle. Maximum of 100 points. Higher score is better. (Cöster, 2014).

To measure performance outcomes, researchers used the Y-balance test (Beazell, 2012; Kamali, 2016), a component of the balance error scoring system on foam with eyes closed (Beazell et al, 2012), the vertical jump test (Hedlund, 2014), baropodometry, and the Step-Down Test (Beazell, 2012).

Six studies measured pain through various methods, including Visual Analogue Scale (VAS) (Shin et al, 2020), Numerical Pain Rating Scale (NPRS) (Gogate et al, 2021), and AOFAS-Pain.

6.3.1 Functional outcomes results

Of the nine studies, six showed statistical significance ($P < .05$) increase in all functional variables (balance, gait, and vertical jump height). One study showed no changes in functional capacities, and one study did not reach statistical significance in all variables; it only showed statistical significance in the posterior load on foot ($p = .015$) and the bilateral anterior load ($p = .02$) (Lopez-Rodriguez et al, 2007).

Shin et al (2020) showed a statistically significant increase in AOFAS-total ($p < 0.001$) and AOFAS-function ($p = 0.001$) scores for the intervention group. The control group (exercise only) also exhibited significant differences in AOFAS-total ($p = 0.031$) and AO-FAS-function ($p = 0.001$), The intervention group displayed only significant differences balance path length ($p = 0.006$), and balance velocity ($p = 0.006$) but neither group improve other balance ability variables. Kamali et al (2016) showed a statistically significant increase in all functional outcomes, but the sham manipulation group exhibited only a significant increase in the Y-balance test's posteromedial distance ($p = 0.030$). Silva et al (2017) revealed significant increases in FAAM ADL and FAAM Sports scores for both the intervention group ($p<.001$) and sham group ($p<.001$).

6.3.2 Pain and pain intensity results

All studies showed a statistical significance ($P < .05$) decrease in pain. Shin et al (2020) measured both VAS-resting pain and VAS-movement pain and found pain to decrease by 89,04% (resting pain) and 80,57% (movement pain), and AOFAS pain score by 6,88 points or 20,01%, but the control group did not present a statistically significant decrease in pain. Silva et al (2017) both groups decreased the VAS pain score, the experimental group by 85,71% and the sham group 78,26%. In the two studies employing the Numerical Pain Rating Scale, the scores decreased by 3,1 points or 52,54% in the experimental group but only by 1,1 point or 18,33% in the control group (Gogate et al, 2021), and in the second study, both groups decreased score, MET group by 4,6 points or 94,85% and Contract release group by 4,2 points or 95,45% (Baidya et al, 2018).

6.3.3 Dorsiflexion Ankle ROM results

Six studies investigated and measured ankle ROM. All studies showed a statistical significance (P < .05) increase in ankle ROM. Four of the studies utilized a Weight-bearing lunge to measured dorsiflexion ROM. Three measured in degrees; the average increase in ROM was 16,26% (Shin et al, 2020; Gogate et al, 2021; Beazell et al, 2012). One measured in cm and ROM increased 1,77 cm or 13,72% in the HVLA group, 2,2 cm or 18,33% in the MWM group, no changes were observed in the control group (Marron-Gomez et al, 2013). Two studies utilized a goniometer: the ROM increase by an average of 39,38% (Silva et al, 2017; Baidya et al, 2018). The control group in Silva's study (Silva et al, 2017) did not show statistical significance (P < .05) increase in ankle dorsiflexion ROM, but the experimental group increase dorsiflexion ROM by 34,09%. In Baidya's study, both groups increased dorsiflexion ROM, contract release by 39,88%, and MET by 43,75% (Baidya et al, 2018).

7 Discussion

7.1 Summary of findings

This review's main objective was to assess the evidence relating to the effects of HVLA and MET on the management of acute and subacute lateral ankle sprains (LAS), and chronic ankle instability (CAI). Analyses of 12 studies revealed that both treatment modalities positively affect pain, ROM, and functional measurements in patients suffering from either LAS or CAI, but that not all interventions are equally effective. Our findings indicate that; (1) manual modalities (independent of type reviewed) plus exercises are the most effective intervention in the management of LAS and CAI; (2) the utility of different modalities depend on the phase of the injury (acute, subacute, or chronic) and (3) what the primary outcome variable is; (4) multiple treatment sessions over an extended period of time are more efficacious than single treatments.

In active people, LAS is a common injury, and in sports it is one of the most often injured joints (Loudon et al, 2014). Startlingly, two-thirds of individuals suffering from ankle injuries do not seek treatment from health care professionals (Pietrosimone, 2012) and athletes tend to return to the field or court without completing a comprehensive rehabilitation program (Alghadir et al, 2020). Nevertheless, mechanical ankle stability is not restored up to 6-12 weeks after injury, and most individuals will continue suffer sequelae and increased risk of re-injury up to one year after the injury (Alghadir et al, 2020).

The question then arises, why do individuals not seek treatment? One possible answer could be that in the first two weeks after injury, pain rapidly decreases (van Rijn, 2008). The decrease in pain level might give a false sense of security. Therefore, the individual might think it is all right to return to normal activities without proper treatment.

7.2 Effects on Pain

Five of 12 studies in this review examined the effects on pain. Three of these studies compared therapeutic modality plus exercise with exercise only, one study compared two different therapeutic modalities plus exercise, and one study only therapeutic modality with a control group. The results of these studies indicate that therapeutic intervention with exercises is more effective than only exercises or treatment.

Shin et al (2020) compared HVLA plus exercise group and an exercise-only group on 31 patients with CAI. The HVLA plus exercise group show a significant difference in resting pain (pre= 11.4, post= 1.25, p = 0.008) and movement pain (pre= 40.65, post= 7.9, p < 0.001), but the control group did not show significant change in pain intensities. Gogate et al (2020) compared joint mobilization with movement plus exercise (EG) with exercise alone (CG) in patients with acute and sub-acute grade I and II inversion ankle sprain. The treatment conditions were evaluated at baseline using the 11 points Numeric Rating Scale to measure pain intensity (EG 5.9, CG 6.0), immediately post-intervention (EG 2.8, CG 4.9), at one (EG 1.1, CG 3.2) and six months (EG 0.5, CG 2.0) post-intervention. Lubbe et al (2015) examined HVLA on the mortise, subtalar, and/or tarsal joints plus rehabilitation exercise (EG) with a control group (CG) receiving rehabilitation exercises only. The patients received six treatments and a maximum of 29 rehabilitation sessions during a five-week treatment period. At week 5, there were statistically significant differences in scores for VAS ((EG pre= 47.3 post= 6.2, CG pre= 40 post= 20, p ≤ .006), but not in the FADI scores (EG pre= 80.4 post= 98.8, CG pre= 75.9 post= 91.3). The results from these three studies show adding mobilization to the treatment intervention is more efficient than exercise alone. These conclusions are supported by a study investigating the effects of proprioceptive and strengthening exercises and manual therapy versus the same exercises in the management of recurrent ankle sprains. The conclusion was that combining manual therapy with strength and proprioceptive exercises resulted in greater improvements in pain and other variables (Plaza-Manzano et al, 2016). A systematic review that investigated effects on neck pain from different intervention types concluded that the combination of manual therapy and exercise is better than either exercise or manual therapy alone (Hidalgoa et al, 2018)

Silva et al (2017) performed anteroposterior mobilization of the talus (grade III of Maitland) on 19 patients with subacute and chronic ankle injuries. The difference in VAS scores between the intervention (Baseline: 2.1 vs. Follow up 0.3) and sham groups (Baseline: 2.3 vs. Follow up 0.5) was not statistically different over the treatment time. The authors stated that the mobilization intervention (grade III Maitland) might not be the best option for controlling pain. These results are supported by the results from a study conducted by Yeo et al (2011), which used Maitland mobilization on 13 patients with a sub-acute unilateral inversion ankle sprain. They found a slight decrease in VAS scores post-intervention. They did however find a significant decrease in pain pressure threshold and concluded that mobilization produces an immediate hypoalgesic effect. The difference between the studies was that Yeo's study administered just one session of Maitland while Silva's study involved six sessions. This could indicate that Maitland mobilization needs more sessions to improve VAS scores but might help improve other pain variables like pain pressure threshold.

Studies have shown that MET effectively decreases pain (Patel, 2020; Kumari, 2016; Yadav, 2015). In this review, only one paper investigated the effect of MET on pain management. The result from that study showed that MET plus Mulligan's MWM decreased pain significantly (pre = 4.85, post = 0.25 - NPRS score), and they concluded that MET plus Mulligan's MWM is an effective intervention to reduce pain. These results are supported by a study investigating MET and the effectiveness of home exercises on myofascial pain in the upper trapezius, and the results show that MET significantly decreased pain (Srikanth, 2015). Mahajan et al (2012) compared the effectiveness of static stretching and MET on pain in subacute mechanical neck pain. The conclusion was that both treatment interventions were efficient in decreasing mechanical neck pain. These results indicate that MET is an effective way of reducing pain and could be a useful technique in treating an inversion ankle sprain, especially subacute and chronic stages. However, it also raises the question of how much influence exercises have on decreasing pain level since both treatment interventions in the study by Baidya et al (2018) and Mahajan et al (2012) showed a reduction in pain levels.

7.3 Effects on Range of motion

Studies have shown that one of the implications of an inversion ankle sprain is decreased dorsiflexion ROM, a major risk factor associated with a recurrent ankle sprain (Hershkovich, 2015; McCriskin, 2015; Fong, 2009; Hertel, 2002). Individuals with CAI exhibit decreased dorsiflexion ROM have other functional inability implications; for example, they may have difficulty performing the Star Excursion Balance Test, specifically the anterior reach (Basnett, 2013; McCann, 2017). They may also display an altered landing strategy which is less efficient at absorbing ground reaction forces (Hoch, 2015) and insufficient dynamic postural control and isometric hip strength (McCann, 2017). Therefore, it is imperative to ensure a treatment intervention correcting this deficit. In this review, six of the 12 studies examined the effects of one or more of HVLA, joint mobilization, and MET on ankle ROM. Three of the studies compared intervention plus exercise with either exercise alone are different types of intervention plus exercise, and three compared intervention with control or sham groups. The results indicate that 1) therapeutic intervention plus exercise are more effective than intervention or exercise alone 2) different therapeutic modalities might be better suited during different phases of the injury 3) it appears that volume of sessions (dose-response) might influence outcomes.

Beazell et al (2012) investigated and compared the effects of HVLA on the proximal and distal tibiofibular joint on individuals with CAI. In that study, both groups increase ankle dorsiflexion ROM, proximal 5° and distal 4°, over three weeks. However, surprisingly the control group (no treatment) also increased ROM by 5°, and there was no significant difference between all groups. The authors speculated that the dorsiflexion changes might have come from the repeated functional outcome assessment test and the difference in the joint structure of the two joints, proximal tibiofibular a synovial joint and distal tibiofibular syndesmotic joint. Their conclusion stated that the results should be interpreted with caution because the interventions were not combined with a rehabilitation program. However, only four treatments were administered during the 21 days intervention period, which might indicate that stimulus, dose-response, or duration of the intervention period, was not enough to create significant changes between groups. Two studies in this review had a higher number of sessions (8 & 12 sessions) and a more extended intervention period (8 and 12 weeks), which resulted in a more significant increase in dorsiflexion ROM 7° (Shin, 2020; Baidya 2018).

The study by Baidya et al (2018) investigated the effect of MET on ankle ROM and found a significant increase in ROM, but this was the only study in this review that examined MET and therefore should be interpreted with caution. However, a systematic review investigating the efficacy of MET in symptomatic and asymptomatic subjects found that when a functional limitation exists, MET can increase the ROM of a joint (Thomas et al, 2019). A study investigating the acute effects of MET on ROM in the glenohumeral joint found it improved posterior shoulder ROM (Moore, 2011). Finally, a study done on cervical ROM found that MET produced a significant increase in cervical ROM. The authors concluded that when treating cervical spine dysfunctions, MET might be a valuable and tool (Burns et al, 2006). These results indicate that MET can be a useful tool in treating an inversion ankle sprain.

One study in our review compared a single intervention of HVLA manipulation to weight-bearing mobilization with movement and placebo groups. They concluded that a single application of either intervention improves ankle dorsiflexion ROM (1.8 cm) for at least two days post-intervention. However, the increase was more significant in weight-bearing mobilization with the movement group (2.0 cm). It is worth mentioning that the authors affirmed that their results contradict other studies investigating the equivalent intervention. The authors stated two plausible reasons for the inconsistent results 1) the different nature of subjects (CAI vs. asymptomatic) 2) the application of three thrusts vs. one thrust. The results from this study indicate that a single intervention can produce an acute increase in dorsiflexion ROM providing that more than single employment of thrust is delivered since a single thrust might be insufficient to stimulate adequate adaptation (Venturini et al, 2007; Wikstrom, 2011). Therefore, administering multiple sessions over an extended period seems more reasonable if a single HVLA thrust is utilized during a treatment session (Wikstrom, 2011).

Concerning different phases of injuries, one study investigated the acute phase utilizing joint mobilization and exercise compared with exercise alone and found a significant increase (10° vs. 3°) increase in dorsiflexion ROM after two weeks (6 sessions). MET plus mulligan's MWM technique was utilized on subacute individuals and showed significant improvements (7° increase) (Baidya et al, 2018). Finally, HVLA plus exercise showed significant improvements (7° increase) in CAI individuals. Therefore, to achieve optimal results, the therapist might need to acknowledge what stage the injury is and what therapeutic modalities are implemented during the intervention (Hing, 2019).

7.4 Effects on function

Studies have shown that patients with CAI demonstrate limitations in functional capacities like impaired postural control, proprioception, sensation, and neuromuscular firing patterns (Hertel et al, 2002; Hertel et al, 2000; Pietrosimone et al, 2012). These deficits can lead to compensatory patterns; for example, patients with impaired postural control will apply hip strategy instead of ankle strategy to maintain balance on the injured leg during single-leg stance (Hertel et al, 2002; Hertel et al, 2000). Impaired proprioception will make individuals more prone to repetitive ankle sprains (Hertel, 2002). Impaired neuromuscular firing patterns can affect gait, balance, and other functional capabilities because of diminished reflex excitability (Pietrosimone et al, 2012). In this review, nine studies examined these functional plus other performance variables. The researchers used the Foot and Ankle Ability Measure (FAAM), the Foot and Ankle Disability Index (FADI), and the American Orthopedic Foot and Ankle Society (AOFAS) scores to assess functional capabilities. To measure performance outcomes, researchers used the Y-balance test, a component of the balance error scoring system on foam with eyes closed, vertical jump test, baropodometric, and the Step-Down Test. These nine studies indicate that HVLA, MET, and/or joint mobilization plus exercise effectively improve functional outcomes compared with therapeutic intervention or exercise alone. For example, Gogate et al (2020) confirmed that joint mobilization plus exercise showed significantly greater increases in FADI score and dynamic balance than the sham group (only exercise). Furthermore, the combination of MET and mulligans movement with mobilization produced a statistically significant ($p<0.05$) improvement in dynamic gait variables, but since this was the only study examining MET in the review, these results should be interpreted with caution.

Studies have shown that patients with CAI demonstrated limitations in functional capacities like impaired postural control, proprioception, sensation, and neuromuscular firing patterns (Hertel et al, 2002; Hertel et al, 2000; Pietrosimone et al, 2012). These deficits can lead to compensatory patterns; for example, patients with impaired postural control will apply hip strategy instead of ankle strategy to maintain balance on the injured leg during single-leg stance (Hertel et al, 2000; Hertel et al, 2002). Impaired proprioception will make individuals more prone to repetitive ankle sprains (Hertel et al, 2002). Impaired neuromuscular firing patterns can affect gait, balance, and other functional capabilities because of diminished reflex excitability (Pietrosimone et al, 2012). In this review, nine studies examined these functional plus other performance variables. The researchers used the Foot and Ankle Ability Measure (FAAM), the Foot and Ankle Disability Index (FADI), and the American Orthopedic Foot and Ankle Society (AOFAS) scores to assess functional capabilities. To measure performance outcomes, researchers used the Y-balance test, a component of the balance error scoring system on foam with eyes closed, vertical jump test, baropodometry, and the Step-Down Test. These nine studies indicate that HVLA, MET, and/or joint mobilization plus exercise effectively improve functional outcomes compared with therapeutic intervention or exercise alone. For example, Gogate et al (2020) confirmed that joint mobilization plus exercise showed significantly greater increases in FADI score and dynamic balance than the sham group (only exercise). Furthermore, the combination of MET and mulligans movement with mobilization produced a statistically significant ($p<0.05$) improvement in dynamic gait variables, but since this was the only study examining MET in the review, these results should be interpreted with caution.

In one study by Beazell et al (2012), no groups suffering CAI exhibited significant differences in improvements in functional outcomes (FAAM, Balance, and Step-down) after an intervention period of three weeks. Because the HVLA interventions (performed on the proximal and distal tibiofibular joints) were not combined with rehabilitation exercises, the researchers urged caution in drawing conclusions. Another reason might be that the targeted joints might not have been susceptible to the used intervention at that stage of the dysfunction. In another study, conducted by Silva et al (2017), both groups, intervention (grade III Maitland mobilization) and sham groups, had significantly increased capacity in both subscales of the FAAM. The authors stated that these findings might be because of the natural healing process of the injury. However, these results might also indicate that the need to combine an exercise program with the therapeutic intervention or that grade III Maitland mobilization does not provide sufficient stimulus for functional improvement (the intervention duration too short or treatment frequency).

As Pietrosimone et al (2012) mentioned previously, altered neuromuscular firing can impair the functional capabilities of individuals suffering from CAI. Hertel et al (2000) reported that in previously injured ankles, fibularis longus, fibularis brevis, and tibialis anterior had significantly longer reaction times to inversion perturbation. The fibularis muscles play an essential role in controlling the ankle's dynamic stability and are the first responders to abrupt ankle inversion stress. However, when inversion stress is delivered at increasing magnitudes during plantar flexion, their response slows down (Hertel et al, 2000). Furthermore, Pietrosimone et al (2012) stated that individuals suffering from CAI have altered descending corticospinal pathways, a bilateral resting motor threshold in fibularis longus which means that the uninjured ankle also decreased corticomotor excitability. One study in this review examined the effects of HVLA on muscle firing patterns. Grindstaff et al (2010) examined the change in fibularis longus and soleus activation following HVLA in individuals with CAI. Individuals were divided into three groups; HVLA on proximal tibiofibular, HVLA on distal tibiofibular, and control groups. Only the distal tibiofibular HVLA demonstrated an acute (30 min) increase in soleus activation, but no significant changes were noticed in the fibularis longus activation. The authors stated that HVLA might not be the appropriate intervention necessary to improve fibularis activation. So, if the intervention's goal is to increase muscle activation of muscles affected by inversion ankle sprains, HVLA might not be the most suitable treatment modality.

It is deserving of mentioning that two studies in this review, one applied single intervention (Hedlund et al, 2014) and the other combination of two therapeutic modalities

(Lopez-Rodriguez et al, 2007), had positive outcomes vertical jump height and stabilometry and baropodometry. This indicates that if there is no possibility to combine exercises with the intervention, applying a combination of treatment modalities might make the treatment more effective.

7.5 Osteopathy and treatment of lateral ankle sprains and chronic ankle instability

Osteopaths can play an essential role in managing LAS and CAI because of the broad range of treatment approaches they have at their disposal (Burke et al, 2013). The results of this review indicate that LAS and CAI both require a broad approach to treatment, taking into consideration different rehabilitation stages. For example, during the acute phase, mobilization with movement (Grade III Maitland) effectively improves dorsiflexion ROM and reduces pain (Gogate et al, 2021) which are considered essential factors early in the rehabilitation process. Later, the osteopaths can incorporate a single or a combination of treatment approaches into a comprehensive rehabilitation program for the most effective treatment results.

7.6 Further research

This review has found support on the effectiveness of HVLA and joint mobilization (MWM) in the management of inversion ankle sprain at both acute and subacute stages, as well as chronic ankle instability. However, there is insufficient evidence for the utilization of MET as a treatment approach for an inversion ankle sprain and CAI because only one paper in this review examined the effects of MET (Baidya et al, 2018). However, it has been confirmed that MET has several beneficial therapeutic mechanisms; (1) neurological and biomechanical (Fryer, 2011); (2) hypoalgesia (Fryer, 2011; Thomas et al, 2019; Faqih et al, 2019); (3) increasing ROM (Thomas et al, 2019; Faqih et al, 2019; Burns & Wells, 2006; Lenehan et al, 2003); (4) lymphatic drainage (Fryer, 2011); (5) changing intramuscular pressure (Fryer, 2011). There is also an overlap between these effects and the consequences of LAS and CAI. Therefore, while further evidence is needed to confirm the efficacy of MET in the management of LAS and CAI, it appears a worthwhile endeavour.

8 Limitations

A time limitation was present due to the literature review being undertaken part time over approximately 3 months, which may have led to relevant studies being missed. Effective searches proved difficult due to mostly large number of hits, resulting in substantial manual screening.

Furthermore, only one study one MET satisfied the inclusion criteria, so robust conclusions on that subject are difficult to draw.

9 Ethical considerations

None of the participants in the reviewed studies were subjected to potentially harmful treatment - all selected articles had eligibility criteria which excluded unsuitable candidates. All studies listed their participants as having volunteered, being recruited, or some variation thereof which indicates voluntary participation. It is unknown if the results of any of these studies were communicated to the participants, and it is unknown how confidentiality was handled. However, all articles either explicitly state that there was informed consent, or that there was ethical approval from some institutional authority.

10 Conflicts of interest

The authors of this review are students at a college of Osteopathy and freely admit that they wish to promote manual therapy in general, and Osteopathy in particular.

Funding: Self.

11 Conclusion

This review's findings demonstrate the efficacy of HVLA in improving dorsiflexion range of motion, decreasing pain, and functional outcomes for individuals with suffering LAS or CAI. MET is an effective tool in the treatment of many conditions, where it reduces pain and improves joint range of motion in individuals. For the treatment of LAS and CAI however, further evidence is needed on the utility and efficacy of MET.

References

Alghadir, A. H. et al. (2020) “Effect of chronic ankle sprain on pain, range of motion, proprioception, and balance among athletes,” International Journal of Environmental Research and Public Health, 17(15), pp. 1–11. doi: 10.3390/ijerph17155318.

Baidya, P. (2018) “Efficacy of Muscle Energy Technique and Contract Relax with Mulligan’s Mobilization with Movement Technique in Subacute Ankle Sprain,” MOJ Yoga & Physical Therapy, 3(1), pp. 7–12. doi: 10.15406/mojypt.2018.03.00036.

Basnett, C. R., Hanish, M. J., Wheeler, T. J., Miriovsky, D. J., Danielson, E. L., Barr, J. B., & Grindstaff, T. L. (2013). Ankle dorsiflexion range of motion influences dynamic balance in individuals with chronic ankle instability. International journal of sports physical therapy, 8(2), 121–128.

Beazell, J. R. et al. (2012) “Effects of a proximal or distal tibiofibular joint manipulation on ankle range of motion and functional outcomes in individuals with chronic ankle instability,” Journal of Orthopaedic and Sports Physical Therapy, 42(2), pp. 125–134. doi: 10.2519/jospt.2012.3729.

Burke, S. R., Myers, R. and Zhang, A. L. (2013) “A profile of osteopathic practice in Australia 2010-2011: A cross sectional survey,” BMC Musculoskeletal Disorders, 14. doi: 10.1186/1471-2474-14-227.

Burns, D. K. and Wells, M. R. (2006) “Gross range of motion in the cervical spine: The effects of osteopathic muscle energy technique in asymptomatic subjects,” Journal of the American Osteopathic Association, 106(3), pp. 137–142. doi: 10.7556/jaoa.2006.106.3.137.

Collins, N., Teys, P. and Vicenzino, B. (2004) “The initial effects of a Mulligan’s mobilization with movement technique on dorsiflexion and pain in subacute ankle sprains,” Manual Therapy, 9(2), pp. 77–82. doi: 10.1016/S1356-689X(03)00101-2.

Delahunt, E., Bleakley, C., Bossard, D., Caulfield, B., Docherty, C., Doherty, C., Fourchet, F., Fong, D., Hertel, J., Hiller, C., Kaminski, T., McKeon, P., Refshauge, K., Remus, A., Verhagen, E., Vicenzino, B., Wikstrom, E. and Gribble, P., 2018. Infographic. International Ankle Consortium Rehabilitation-Oriented Assessment. British Journal of Sports Medicine, 53(19), pp.1248-1249.

Delahunt, E. et al. (2013) “Joint mobilization acutely improves landing kinematics in chronic ankle instability,” Medicine and Science in Sports and Exercise, 45(3), pp. 514–519. doi: 10.1249/MSS.0b013e3182746d0a.

DeMers, M. S., Hicks, J. L. and Delp, S. L. (2017) “Preparatory co-activation of the ankle muscles may prevent ankle inversion injuries,” Journal of Biomechanics, 52, pp. 17–23. doi: 10.1016/j.jbiomech.2016.11.002.

Doherty, C. et al. (2017) “Treatment and prevention of acute and recurrent ankle sprain: An overview of systematic reviews with meta-analysis,” British Journal of Sports Medicine, pp. 113–125. doi: 10.1136/bjsports-2016-096178.

Eisenhart, A. W., Gaeta, T. J. and Yens, D. P. (2003) “Osteopathic manipulative treatment in the emergency department for patients with acute ankle injuries,” Journal of the American Osteopathic Association, 103(9), pp. 417–421. doi: 10.7556/jaoa.2003.103.9.417.

Faqih, A. I. et al. (2019) “Effects of muscle energy technique on pain, range of motion and function in patients with post-surgical elbow stiffness: A randomized controlled trial,” Hong Kong Physiotherapy Journal, pp. 25–33. doi: 10.1142/S1013702519500033.

Fawkes, C. A. et al. (2014) “A profile of osteopathic care in private practices in the United Kingdom: A national pilot using standardised data collection,” Manual Therapy, 19(2), pp. 125–130. doi: 10.1016/j.math.2013.09.001.

Fong, D. T. P. et al. (2007) “A systematic review on ankle injury and ankle sprain in sports,” Sports Medicine, 37(1), pp. 73–94. doi: 10.2165/00007256-200737010-00006.

Fong, D. T. et al. (2009) “Understanding acute ankle ligamentous sprain injury in sports,” BMC Sports Science, Medicine and Rehabilitation, 1(1). doi: 10.1186/1758-2555-1-14.

Friel, K. et al. (2006) “Ipsilateral hip abductor weakness after inversion ankle sprain,” Journal of Athletic Training, 41(1), pp. 74–78.

Fryer, G. (2011) “Muscle energy technique: An evidence-informed approach,” International Journal of Osteopathic Medicine, 14(1), pp. 3–9. doi: 10.1016/j.ijosm.2010.04.004.

Gogate, N., Satpute, K. and Hall, T. (2021) “The effectiveness of mobilization with movement on pain, balance and function following acute and sub acute inversion ankle sprain – A randomized, placebo controlled trial,” Physical Therapy in Sport, 48, pp. 91–100. doi: 10.1016/j.ptsp.2020.12.016.

Grindstaff, T. L. et al. (2011) “Immediate effects of a tibiofibular joint manipulation on lower extremity H-reflex measurements in individuals with chronic ankle instability,” Journal of Electromyography and Kinesiology, 21(4), pp. 652–658. doi: 10.1016/j.jelekin.2011.03.011.

Halabchi, F. and Hassabi, M. (2020) “Acute ankle sprain in athletes: Clinical aspects and algorithmic approach,” World Journal of Orthopaedics, 11(12), pp. 534–558. doi: 10.5312/wjo.v11.i12.534.

Hedlund, S. et al. (2014) “Effect of chiropractic manipulation on vertical jump height in young female athletes with talocrural joint dysfunction: A single-blind randomized clinical pilot trial,” Journal of Manipulative and Physiological Therapeutics, 37(2), pp. 116–123. doi: 10.1016/j.jmpt.2013.11.004.

Hershkovich, O. et al. (2015) “A Large-Scale Study on Epidemiology and Risk Factors for Chronic Ankle Instability in Young Adults,” Journal of Foot and Ankle Surgery, 54(2), pp. 183–187. doi: 10.1053/j.jfas.2014.06.001.

Hertel J. (2000) Functional instability following lateral ankle sprain. Sports Med. 29(5):361-71. doi: 10.2165/00007256-200029050-00005.

Hertel, J. (2002) “Functional anatomy, pathomechanics, and pathophysiology of lateral ankle instability,” Journal of Athletic Training, 37(4), pp. 364–375.

Hidalgo, B. et al. (2018) “The immediate effects of two manual therapy techniques on ankle musculoarticular stiffness and dorsiflexion range of motion in people with chronic ankle rigidity: A randomized clinical trial,” Journal of Back and Musculoskeletal Rehabilitation, 31(3), pp. 515–524. doi: 10.3233/BMR-170963.

Hoch, M. C. et al. (2014) “Effect of a 2-week joint-mobilization intervention on single-limb balance and ankle arthrokinematics in those with chronic ankle instability,” Journal of Sport Rehabilitation, 23(1), pp. 18–26. doi: 10.1123/JSR.2012-0125.

Hoch, M. C. et al. (2015) “Weight-bearing dorsiflexion range of motion and landing biomechanics in individuals with chronic ankle instability,” Journal of Athletic Training, 50(8), pp. 833–839. doi: 10.4085/1062-6050-50.5.07.

Hubbard, T. and Wikstrom E. (2010) “Ankle sprain: pathophysiology, predisposing factors, and management strategies,” Open Access Journal of Sports Medicine, p. 115. doi: 10.2147/oajsm.s9060.

Joseph, L. C. (2010) “the Relative Effectiveness of Muscle Energy Technique Compared To Manipulation in the Treatment of Chronic Stable Ankle Inversion Sprains,” American chiropractice medicine, pp. 8–22.

Kamali, F., Sinaei, E. and Bahadorian, S. (2017) “The immediate effect of talocrural joint manipulation on functional performance of 15–40 years old athletes with chronic ankle instability: A double-blind randomized clinical trial,” Journal of Bodywork and Movement Therapies, 21(4), pp. 830–834. doi: 10.1016/j.jbmt.2017.01.010.

Kumari, C. et al. (2016) “Efficacy of Muscle Energy Technique As Compared to Proprioceptive Neuromuscular Facilitation Technique in Chronic Mechanical Neck Pain: A Randomized Controlled Trial,” International Journal of Health Sciences & Research (www.ijhsr.org), 6(November), p. 11. Available at: www.ijhsr.org.

Lenehan, K. L., Fryer, G. and McLaughlin, P. (2003) “The effect of muscle energy technique on gross trunk range of motion,” Journal of Osteopathic Medicine, 6(1), pp. 13–18. doi: 10.1016/s1443-8461(03)80004-7.

López-Rodríguez, S. et al. (2007) “Immediate Effects of Manipulation of the Talocrural Joint on Stabilometry and Baropodometry in Patients With Ankle Sprain,” Journal of Manipulative and Physiological Therapeutics, 30(3), pp. 186–192. doi: 10.1016/j.jmpt.2007.01.011.

Lorenz, H. and Longaker, M., 2008. Wounds: Biology, Pathology, and Management. Surgery, pp.191-208.

Loudon, J. K., Reiman, M. P. and Sylvain, J. (2014) “The efficacy of manual joint mobilisation/manipulation in treatment of lateral ankle sprains: A systematic review,” British Journal of Sports Medicine, pp. 365–370. doi: 10.1136/bjsports-2013-092763.

Lubbe, D. et al. (2015) “Manipulative therapy and rehabilitation for recurrent ankle sprain with functional instability: A short-term, assessor-blind, parallel-group randomized trial,” Journal of Manipulative and Physiological Therapeutics, 38(1), pp. 22–34. doi: 10.1016/j.jmpt.2014.10.001.

Mahajan, R., Kataria, C., & Bansal, K. (2012). Comparative Effectiveness of Muscle Energy Technique and Static Stretching for Treatment of Subacute Mechanical Neck Pain, International Journal of Health and Rehabilitation Sciences, 1(1): 16-24. doi: 10.5455/ijhrs.00000004

Marrón-Gómez, D., Rodríguez-Fernández, Á. L. and Martín-Urrialde, J. A. (2015) “The effect of two mobilization techniques on dorsiflexion in people with chronic ankle instability,” Physical Therapy in Sport, 16(1), pp. 10–15. doi: 10.1016/j.ptsp.2014.02.001.

Martínez-Segura, R. et al. (2006) “Immediate Effects on Neck Pain and Active Range of Motion After a Single Cervical High-Velocity Low-Amplitude Manipulation in Subjects Presenting with Mechanical Neck Pain: A Randomized Controlled Trial,” Journal of Manipulative and Physiological Therapeutics, 29(7), pp. 511–517. doi: 10.1016/j.jmpt.2006.06.022.

McCann, R. S. et al. (2017) “Hip strength and star excursion balance test deficits of patients with chronic ankle instability,” Journal of Science and Medicine in Sport, 20(11), pp. 992–996. doi: 10.1016/j.jsams.2017.05.005.

McCriskin, B. J. et al. (2015) “Management and prevention of acute and chronic lateral ankle instability in athletic patient populations,” World Journal of Orthopaedics, pp. 161–171. doi: 10.5312/wjo.v6.i2.161.

McKay, G. D. et al. (2001) “Ankle injuries in basketball: Injury rate and risk factors,” British Journal of Sports Medicine, 35(2), pp. 103–108. doi: 10.1136/bjsm.35.2.103.

Moore, S. D. et al. (2011) “The immediate effects of muscle energy technique on posterior shoulder tightness: A randomized controlled trial,” Journal of Orthopaedic and Sports Physical Therapy, pp. 400–407. doi: 10.2519/jospt.2011.3292.

Nambi, G. et al. (2013) “Difference in effect between ischemic compression and muscle energy technique on upper trepezius myofascial trigger points: Comparative study,” International Journal of Health & Allied Sciences, 2(1), p. 17. doi: 10.4103/2278-344x.110570.

Ng, Z. D. & De, S. 2007. Modified Brostrom-Evans-Gould technique for recurrent lateral ankle ligament instability. Journal of Orthopaedic Surgery, 15(3), pp. 306-10. doi:10.1177/230949900701500313

Nogueira de Almeida, B. S., Sabatino, J. H. and Giraldo, P. C. (2010) “Effects of High-Velocity, Low-Amplitude Spinal Manipulation on Strength and the Basal Tonus of Female Pelvic Floor Muscles,” Journal of Manipulative and Physiological Therapeutics, 33(2), pp. 109–116. doi: 10.1016/j.jmpt.2009.12.007.

Ortega-Avila, A. B. et al. (2020) “Conservative Treatment for Acute Ankle Sprain: A Systematic Review,” Journal of Clinical Medicine, 9(10), p. 3128. doi: 10.3390/jcm9103128.

Patel, D. H. and Amit, M. (2020) “Comparative Study Between Muscle Energy Technique Versus Therapeutic Taping on Pain and Disability in Patients with Patellofemoral Arthritis,” 14(3), pp. 73–79.

Pietrosimone, B. G. and Gribble, P. A. (2012) “Chronic ankle instability and corticomotor excitability of the fibularis longus muscle,” Journal of Athletic Training, 47(6), pp. 621–626. doi: 10.4085/1062-6050-47.6.11.

Postle, K., Pak, D. and Smith, T. O. (2012) “Effectiveness of proprioceptive exercises for ankle ligament injury in adults: A systematic literature and meta-analysis,” Manual Therapy, 17(4), pp. 285–291. doi: 10.1016/j.math.2012.02.016.

Physiotherapy Evidence Database. 2021. PEDro. [online] Available at: <https://pedro.org.au/> [Accessed 10 February 2021].

Prisma.thetacollaborative.ca. 2021. PRISMA Diagram Generator. [online] Available at: <http://prisma.thetacollaborative.ca/> [Accessed 20 March 2021].

Rijn, R. M. Van et al. (2008) “What Is the Clinical Course of Acute Ankle Sprains? A Systematic Literature Review.” doi: 10.1016/j.amjmed.2007.11.018.

Shin, H. J. et al. (2020) “Manipulative therapy plus ankle therapeutic exercises for adolescent baseball players with chronic ankle instability: A single-blinded randomized controlled trial,” International Journal of Environmental Research and Public Health, 17(14), pp. 1–13. doi: 10.3390/ijerph17144997.

Silva, R. D. et al. (2017) “Effects of Anteroposterior Talus Mobilization on Range of Motion, Pain, and Functional Capacity in Participants With Subacute and Chronic Ankle Injuries: A Controlled Trial,” Journal of Manipulative and Physiological Therapeutics, 40(4), pp. 273–283. doi: 10.1016/j.jmpt.2017.02.003.

Smith, M. and Fryer, G. (2008) “A comparison of two muscle energy techniques for increasing flexibility of the hamstring muscle group,” Journal of Bodywork and Movement Therapies, 12(4), pp. 312–317. doi: 10.1016/j.jbmt.2008.06.011.

Srikanth, M., Srikumari, V. and Madhavi, K. (2015) “Effectiveness of Muscle Energy Technique on Pain & Cervical Range of Motion in Patients with Myofascial Pain in Upper Trapezius,” International Journal of Physiotherapy, 2(1), p. 333. doi: 10.15621/ijphy/2015/v2i1/60040.

Statistiska Centralbyrån. 2021. Sveriges befolkning. [online] Available at: <https://www.scb.se/hitta-statistik/sverige-i-siffror/manniskorna-i-sverige/sveriges-befolkning/> [Accessed 21 March 2021].

Sturion, L. A., Nowotny, A. H., Barillec, F., Barette, G., Santos, G. K., Teixeira, F. A., Silva, R. D. 2020. Comparison between high-velocity low-amplitude manipulation and muscle energy technique on pain and trunk neuromuscular postural control in male workers with chronic low back pain: A randomised crossover trial. The South African Journal Of Physiotherapy, 76(1), pp. e1-e9. doi:10.4102/sajp.v76i1.1420

Thomas, E. et al. (2019) "The efficacy of muscle energy techniques in symptomatic and asymptomatic subjects: A systematic review," Chiropractic and Manual Therapies, 27(1). doi: 10.1186/s12998-019-0258-7.

Van den Bekerom, M. P. J. et al. (2013) "Management of acute lateral ankle ligament injury in the athlete," Knee Surgery, Sports Traumatology, Arthroscopy, 21(6), pp. 1390–1395. doi: 10.1007/s00167-012-2252-7.

Vuurberg, G. et al. (2018) "Diagnosis, treatment and prevention of ankle sprains: Update of an evidence-based clinical guideline," British Journal of Sports Medicine, 52(15), p. 956. doi: 10.1136/bjsports-2017-098106.

Weerasekara, I. et al. (2018) "Clinical Benefits of Joint Mobilization on Ankle Sprains: A Systematic Review and Meta-Analysis," Archives of Physical Medicine and Rehabilitation, 99(7), pp. 1395-1412.e5. doi: 10.1016/j.apmr.2017.07.019.

Venturini, C. et al. (2007) "Study of the Force Applied During Anteroposterior Articular Mobilization of the Talus and its Effect on the Dorsiflexion Range of Motion," Journal of Manipulative and Physiological Therapeutics, 30(8), pp. 593–597. doi: 10.1016/j.jmpt.2007.08.002.

Wikimedia Commons, 2006. The Human ankle. [image] Available at: <https://commons.wikimedia.org/wiki/File:Ankle.PNG> [Accessed 21 March 2021].

Wikstrom, E. and McKeon, P. (2011) “Manipulative therapy effectiveness following acute lateral ankle sprains,” Transport Engineer. Available at: http://search.proquest.com.sci-hub.io/openview/53da8e4d5a5a1b0ac496e92befef5902/1?pq-origsite=gscholar.

Wikstrom, E. A., Hubbard-Turner, T. and McKeon, P. O. (2013) “Understanding and Treating Lateral Ankle Sprains and their Consequences: A Constraints-Based Approach,” Sports Medicine, 43(6), pp. 385–393. doi: 10.1007/s40279-013-0043-z.

Wikstrom, E. A. and McKeon, P. O. (2017) “Predicting manual therapy treatment success in patients with chronic ankle instability: Improving self-reported function,” Journal of Athletic Training, 52(4), pp. 325–331. doi: 10.4085/1062-6050-52.2.07.

Yadav, H. and Goyal, M. (2015) “Efficacy of Muscle Energy Technique and Deep Neck Flexors Training in Mechanical Neck Pain- a Randomized Clinical Trial,” International Journal of Therapies and Rehabilitation Research, 4(1), p. 52. doi: 10.5455/ijtrr.00000048.

Yeo, H. K. and Wright, A. (2011) “Hypoalgesic effect of a passive accessory mobilisation technique in patients with lateral ankle pain,” Manual Therapy, 16(4), pp. 373–377. doi: 10.1016/j.math.2011.01.001.

Xue, X. et al. (2020) “Chronic ankle instability is associated with proprioception deficits: A systematic review with meta-analysis,” Journal of Sport and Health Science, 00, pp. 1–10. doi: 10.1016/j.jshs.2020.09.014.

PEDro scale and quality assessment

PEDro assessment criteria are shown in Table 8.

Table 8. PEDro scale criteria (PEDro, 2021)

1	Eligibility criteria reported
2	Random assignment of subjects
3	Concealed allocation
4	Groups similar at baseline regarding most important prognostic indicator
5	Blinding of participants
6	Blinding of therapists who administered the intervention
7	Blinding of assessors who measured key outcomes
8	Measures of at least one key outcome were obtained from more than 85% of initial participants
9	All participants received treatment or control condition as allocated
10	Results of between-group statistical comparisons are reported
11	Study provides both point measures and measures of variability for at least one key outcome

Criteron 1 asses external validity. Criteria 2-9 asses internal validity. Criteria 10-11 assess interpretability.

PEDRO scale assessment of articles selected for quality assessment are shown in Table 9.

Table 9. PEDro assessment scores

Reference	Eligibility criteria specified	Randomly allocated subjects	Concealed allocation	Groups similar at baseline	Blinding of all subjects	Blinding of therapists	Blinding of assessors	One or more key outcome from >85% of initial subjects	All subjects with outcome measures availible received treatment or control condition	Between group stat comparisons reported for <=1 key outcome	Point measures and measures of variability for <=1 key outcome	Total
Hedlund et al, 2014	1	1	1	1	1	0	1	1	1	1	1	10
Kamali et al, 2016	1	1	1	1	1	0	1	1	1	1	0	9
Gogate et al, 2021	1	1	1	1	0	0	1	1	1	1	1	9
Marron-Gomez et al, 2013	1	1	0	1	1	0	1	1	1	1	1	9
Wikstrom & McKeon, 2017	1	1	1	1	0	0	0	1	1	1	1	8
Shin et al, 2020	1	1	0	1	0	0	1	1	1	1	1	8
Lubbe et al, 2015	1	1	0	1	0	0	1	1	1	1	1	8
Lopez-Rodriguez et al, 2007	1	0	0	1	0	0	1	1	1	1	1	7
Baidya et al, 2018	1	1	0	1	0	0	0	1	1	1	1	7
Silva et al, 2017	1	1	1	1	1	0	0	0	1	1	1	8
Grindstaff et al, 2011	1	1	1	1	0	0	1	1	1	1	1	9
Hoch et al, 2014	1	0	0	1	0	0	0	1	1	0	1	5
Beazell et al, 2012	1	1	0	1	0	0	1	1	1	1	1	8

Hoch et al (2014) excluded for having low score.