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The effect of two mobilization techniques on dorsiflexion in people with chronic ankle instability

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ABSTRACT

Objective: To compare the effect of two manual therapy techniques, mobilization with movement (WB-MWM) and talocrural manipulation (HVLA), for the improvement of ankle dorsiflexion in people with chronic ankle instability (CAI) over 48 h.
Design: Randomized controlled clinical trial.
Setting: University research laboratory.
Participants: Fifty-two participants (mean ± SD age, 20.7 ± 3.4 years) with CAI were randomized to WB-MWM ($n = 18$), HVLA ($n = 19$) or placebo group ($n = 15$).
Main Outcome Measures: Weight-bearing ankle dorsiflexion measured with the weight-bearing lunge. Measurements were obtained prior to intervention, immediately after intervention, and 10 min, 24 h and 48 h post-intervention.
Results: There was a significant effect × time ($F_{4,192} = 20.65$; $P < 0.001$) and a significant time × group interactions ($F_{8,192} = 6.34$; $P < 0.001$). *Post hoc* analysis showed a significant increase of ankle dorsiflexion in both WB-MWM and HVLA groups with respect to the placebo group with no differences between both active treatment groups.
Conclusion: A single application of WB-MWM or HVLA manual technique improves ankle dorsiflexion in people with CAI, and the effects persist for at least two days. Both techniques have similar effectiveness for improving ankle dorsiflexion although WB-MWM demonstrated greater effect sizes.

1. Introduction

Ankle sprains are the most common injury incurred during sports activities (Collins, Teys, & Vicenzino, 2004; Morrison & Kaminski, 2007) and it has been reported that during the period from 2005 to 2006 ankle sprains accounted for 22.6% of all sports injuries in adolescent high school athletes (Nelson, Collins, Yard, Fields, & Comstock, 2007). It is estimated that between 20% and 40% of ankle sprains will result in chronic ankle instability (CAI) with up to 70% reported in specific sports such as basketball (Valderrabano, Wiewiorski, Frigg, Hintermann, & Leumann, 2007; Valderrabano et al., 2006). CAI is defined as a set of residual symptoms that can occur after an initial ankle sprain and include chronic pain, episodes of giving way, recurrent sprains, and swelling (Delahunt et al., 2010; Ross, Guskiewicz, Gross, & Yu, 2008). CAI may not only limit activity, but also may lead to an increased risk of osteoarthritis and articular degeneration at the ankle (Hubbard, Hertel, & Sherbondy, 2006; Valderrabano, Hintermann, Horisberger, & Fung, 2006).

A deficit in dorsiflexion is common after an acute or subacute ankle sprain (Collins et al., 2004) as well as in subjects with CAI (Drewes, McKeon, Kerrigan, & Hertel, 2009; Hoch et al., 2012). The restriction of this movement affects daily activities such as walking, running, stair-climbing and squatting (Bennell, Talbot, Wajswelner, Techovanich, & Kelly, 1998; Green, Refshauge, Crosbie, & Adams, 2001) and although the factors that predispose to reinjury of the ankle are not conclusively evidence based, a deficit in dorsiflexion has been shown to be associated with the recurrence of ankle sprains in some studies (Baker, Beynnon, & Renstrom, 1997; Bennell et al., 1998; Pope, Herbert, & Kirwan, 1998; Vicenzino, Branjerdporn, Teys, & Jordan, 2006). Altered arthrokinematics is a mechanical deficiency outlined in the Hertel (2002) paradigm of insufficiencies and thought to contribute to CAI. Pope et al. (1998) reported that a restriction in ankle dorsiflexion increased the risk

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of incurring an ankle sprain in 1093 Australian Army recruits (likelihood ratio = 7.65; $P = 0.006$).

Manual therapy is frequently used by physical therapists after injury to improve range of motion, alleviate pain, and facilitate return to function (Green et al., 2001; Vicenzino et al., 2006). There are several manual therapy techniques used to restore dorsiflexion with the most common being an antero-posterior (AP) passive accessory joint mobilization of the talus on the tibia (De Souza, Venturini, Teixeira, Chagas, & De Resende, 2008; Green et al., 2001; Venturini et al., 2007), a high-velocity thrust manipulation of the talocrural joint (Andersen, Fryer, & McLaughlin, 2003; Dananberg, Shearstone, & Guilliano, 2000; Fryer, Mudge, & McLaughlin, 2002; Nield, Davis, Latimer, Maher, & Adams, 1993) and a mobilization with movement (MWM) as described by Mulligan (Collins et al., 2004; Mulligan, 1999; O'Brien & Vicenzino, 1998; Vicenzino et al., 2006). Suggested bases for the therapeutic mechanism of mobilization or manipulation techniques used for the restoration of ankle dorsiflexion is a suspected positional fault in the distal fibula (Hubbard et al., 2006) and a limitation in posterior glide of the talus observed after an ankle sprain (Denegar, Hertel, & Fonseca, 2002; Vicenzino et al., 2006). The latter technique is suggested to facilitate the restoration of normal arthrokinematics of the talocrural joint, improving the positioning of its rotational center and its articular congruence (Beazell et al., 2012; Venturini et al., 2007).

The efficacy of the manipulation and mobilization for the improvement of ankle dorsiflexion has been widely investigated in previous studies (Andersen et al., 2003; Beazell et al., 2009, 2012; Collins et al., 2004; De Souza et al., 2008; Delahunt, Cusack, Wilson, & Docherty, 2013; Fryer et al., 2002; Green et al., 2001; Hoch & McKeon, 2011; Hoch et al., 2012; O'Brien & Vicenzino, 1998; Venturini et al., 2007; Vicenzino et al., 2006), with some studies demonstrating a positive effect (Collins et al., 2004; Green et al., 2001; O'Brien & Vicenzino, 1998; Pellow & Brantingham, 2001; Venturini et al., 2007; Vicenzino et al., 2006) and some studies demonstrating a negative effect in both asymptomatic (Andersen et al., 2003; Fryer et al., 2002; Nield et al., 1993) and CAI subjects (Beazell et al., 2009, 2012). However, to date there are limited studies on the comparative effect of mobilization techniques versus manipulation. Therefore, the aim of this study was to compare the effect of two manual techniques, MWM and talocrural manipulation, for the improvement of ankle dorsiflexion in people with CAI over a 48 h period.

2. Methods

2.1. Participants

Fifty-two participants (31 males, 21 females) aged from 15 to 36 years old (mean ± SD: 20.7 ± 3.4 years) with CAI volunteered and qualified for participation (Fig. 1 and Table 1). Inclusion criteria were: a past history of at least one unilateral ankle sprain which needed weight-bearing rest (Caulfried & Garrett, 2004; Dayakidis & Boudolos, 2006; Delahunt, Monaghan, & Caulfried, 2006, 2007); current episodes of ankle instability in the form of giving way, pain and/or subjective decrease of function; less than 24 points in the Spanish version of the Cumberland Ankle Instability Tool (CAIT-Sv) (Rodríguez-Fernández, 2013) to ensure the existence of CAI (De Noronha, Refshauge, Kilbreath, & Crosbie, 2007; Delahunt, O'Driscoll, & Moran, 2008).

The CAIT-Sv is the Spanish cross-cultural adaptation of the Cumberland Ankle Instability Tool (CAIT). Both scales are considered valid for the discrimination of subjects with CAI. CAIT is a self-reported questionnaire for ankle instability. It consists of 9 items about pain, stability in different situations and the response

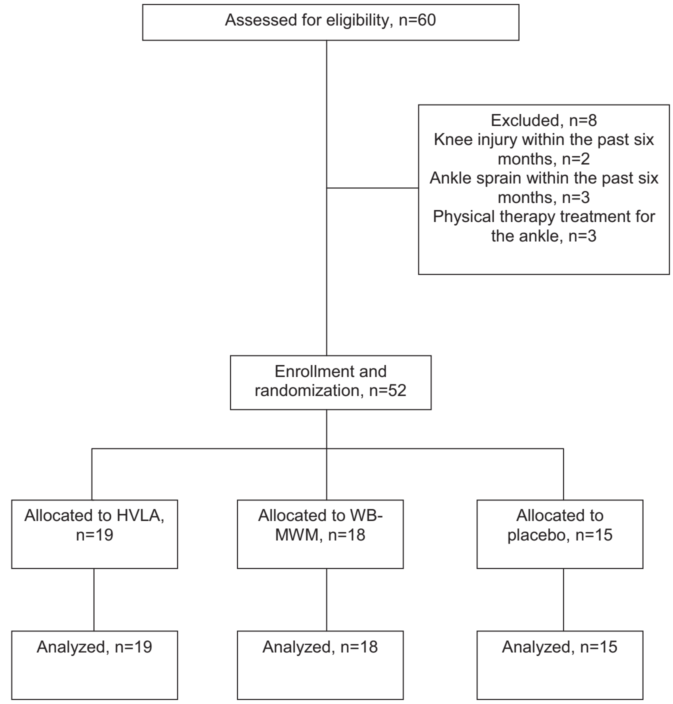

Fig. 1. Consort flow chart. HVLA: High velocity and low amplitude manipulation; WB-MWM: Weight-bearing mobilization with movement.

to typical ankle sprains. The maximum score is 30, which corresponds with the best ankle stability. CAIT has a sensibility and a specificity of 82.9% and 74.7% respectively for a cut point of 27.5 (Hiller, Refshauge, Bundy, Herber, & Kilbreath, 2006). The CAIT-Sv showed adequate values of internal consistency, construct validity, reliability, floor and ceiling effects and responsiveness (Rodríguez-Fernández, 2013).

Exclusion criteria were lower extremity injury or surgery within the past six months or physical therapy treatment of the lower extremities at the time of the study. Participants were recruited as a sample of convenience from a university community and soccer

Table 1
Participants demographics.

	HVLA group ($n = 19$)	MWM group ($n = 18$)	Placebo group ($n = 15$)	P value
Age (years)	20.6 ± 2.5	21.1 ± 5	20.3 ± 1.4	0.82
Height, m	1.77 ± 0.1	1.76 ± 0.1	1.74 ± 0.12	0.67
Weight, kg	72.7 ± 11.4	69.04 ± 15.4	70.6 ± 15.1	0.73
BMI	23.1 ± 2.4	22.2 ± 3.4	23.1 ± 2.3	0.55
CAIT-Sv	19 ± 2.9	18.2 ± 4.97	20.3 ± 1.4	0.25
Number of sprains	2.6 ± 1.3	3.11 ± 1.6	2.7 ± 1.05	0.50
Last ankle sprain, years	3.1 ± 2.3	2.7 ± 2.94	1.8 ± 1.01	0.27
Male/female	13/6	9/9	9/6	0.56
Sport practice, yes/no	14/5	13/5	10/5	0.93
MAI/FAI	4/15	7/11	4/11	0.51
Dominance, right/left	18/1	15/3	14/1	0.51

HVLA: High velocity and low amplitude manipulation; MWM: Mobilization with movement; BMI: Body mass index; CAIT-Sv: Cumberland Ankle Instability Tool (Spanish Version); MAI: Mechanical ankle instability; FAI: Functional ankle instability. Values are presented as mean ± SD for quantitative data and number of participants for qualitative data. Comparison was made with one-way ANOVA for quantitative data and with chi-square for qualitative data. There was no significant difference between groups.

and basketball teams from the Comunidad Autónoma de Madrid (Spain), while the interventions were performed in the Physical Therapy Research Unit of CEU-San Pablo University.

This study was approved by the ethics committee of CEU-San Pablo University, and all subjects signed an informed consent before data collection. If subjects were aged less than 18 years old, the informed consent was signed by his/her parent.

2.2. Outcome measure (dependent variable)

The dependent variable in this study was weight-bearing ankle dorsiflexion measured with the weight-bearing lunge (Beazell et al., 2009, 2012; Collins et al., 2004; O'Brien & Vicenzino, 1998; Vicenzino et al., 2006) (Fig. 2). This was performed standing, with the second toe, center of the heel and knee kept in a plane perpendicular to the wall. The heel had to be kept firmly in contact with the ground during the test. The participant then lunged forward until the anterior knee contacted the wall and maximum dorsiflexion was obtained without lifting the heel from the ground. The distance between the second toe and the wall was recorded to estimate an indirect measure of ankle dorsiflexion (Collins et al., 2004). This method has shown a high intra-rater reliability with intraclass correlation coefficients ($ICC_{3,3}$) ranging between 0.97 and 0.98 (95% confidence interval [CI]: 0.9–0.99) and a standard error of the mean (SE_{mean}) 0.5–0.6 cm. The inter-rater reliability has also been shown to be high with an $ICC_{2,3}$ of 0.99 (95% CI: 0.97–0.99) and a SE_{mean} of 0.4 cm (Bennell et al., 1998). These values are similar to those shown by Konor, Morton, Eckerson, and Grindstaff (2012) in a recent study which demonstrated a minimal detectable change between 1.1 and 1.5 cm.

Dorsiflexion was assessed before the intervention, immediately after the intervention, and again at 10 min, 24 h and, 48 h after the intervention. All the measurements were made in the laboratory with the same temperature conditions and at a similar time of the day in order to avoid bias.

2.3. Interventions (independent variables)

The independent variable was the treatment condition that consisted of a weight-bearing MWM (WB-MWM), a high velocity and low amplitude manipulation (HVLA) of the talocrural joint condition and a placebo condition. All interventions were made by a physical therapist with 15 years experience in the treatment of musculoskeletal conditions.

The MWM was administered with the participant relaxed, standing on a couch. A nonelastic belt was passed around the distal leg of the participant and the physical therapist's pelvis who was positioned in front of the participant's leg. To avoid pain at the contact point of the belt with the Achilles tendon, foam cushioning was used. Then the therapist applied a sustained posteroanterior glide to the tibia through the belt by leaning backwards while the talus and forefoot were fixed with the space between the thumb and the second right hand finger. The other hand was positioned anteriorly over the proximal tibia to direct the knee over the line of the second and third toes. Then, the participant was instructed to perform a slow dorsiflexion movement until the first onset of pain or end of range motion without heel lift off the couch. The belt was kept perpendicular to the tibia throughout the movement. 10 repetitions were applied in one set (Fig. 3).

The talocrural joint HVLA manipulation was applied with the participant lying supine on a couch. The therapist grasped the foot of the participant with one hand with his fifth finger contacting the anterior aspect of the ankle at the talus. The other hand of the therapist reinforced these contact points. Both thumbs of the therapist were placed on the sole of the foot. The therapist took-up slack with a slight caudal traction focused on the talocrural joint with the ankle in neutral position. The therapist then applied a high-velocity thrust distraction technique to the talocrural joint. Independent of the achievement of an audible cavitation, three distraction thrusts were applied in one set (Fig. 4).

The placebo condition replicated the WB-MWM condition with a number of exceptions to ensure the absence of therapeutic effect following the guidelines of Collins et al. (2004). The belt was placed around the calcaneum and the therapist only applied minimal tension to reduce the slack in the belt. One hand remained on the proximal tibia, while the other hand was positioned across the metatarsal bases. The participant had to produce a small inner range movement into dorsiflexion while the belt was perpendicular to the leg. As with the WB-MWM technique, one set of 10 repetitions was performed.

2.4. Experimental procedure

A randomized, double-blind, repeated measures, parallel control design was used. The randomization of the interventions was performed by throwing a die. After signing an informed consent, participants were interviewed in order to compile clinical information about ankle sprain history and other injuries, current symptoms and sport's practice. During this interview, participants completed the CAIT-Sv questionnaire. After this, a manual exploration of mechanical stability of the ankle was performed using the anterior drawer test. This test is considered reliable for chronic conditions with an ICC of 0.94 (95% IC: 0.88–0.94) (De Vries, Kerkhoffs, Blankewort, & Van Dijk, 2010). When all data were collected, a measure of the weight-bearing lunge was made by an

Fig. 2. Weight-bearing lunge measurement. The red line shows the distance between the wall and the second toe of the subject. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Fig. 3. Weight-bearing mobilization with movement for the improvement of ankle dorsiflexion.

Fig. 4. Talocrural joint high velocity and small amplitude manipulation.

evaluator who was blind to the treatment condition applied by the physical therapist. The participant then received either WB-MWM, HVLA, or placebo intervention. The physical therapist who applied these treatments was blinded to the pre- and post-treatment dorsiflexion measurement results. The dorsiflexion measure was then repeated immediately after the intervention and again after 10 min, 24 h and, 48 h by the same evaluator.

To ensure participants were blinded to the interventions they were informed that the study was evaluating the effects of a manual therapy technique on ankle dorsiflexion but they did not receive information about the existence of three different interventions.

2.5. Statistical analysis

Data were analyzed with SPSS version 15.0 (SPSS Inc, Chicago, IL). Mean and SD for each variable were calculated. A normal distribution of quantitative data was assessed by the Kolmogorov–Smirnov test. Baseline data between groups were compared using chi-square tests of independence for categorical data and one-way analysis of variance (ANOVA) for continuous data. A repeated measure ANOVA with time (pre-intervention, immediately post-intervention, 10 min, 24 h and 48 h post-intervention) as the within-subjects factor, and group (MWM, HVLA or placebo) as the between-subject factor (independent variable) was made. Bonferroni *post hoc* analysis was used. Within-group and between-group effect sizes were calculated using the Cohen (1988) *d* coefficient. An effect size of less than 0.2 reflects a negligible mean difference; between 0.2 and 0.5, a small difference; between 0.5 and 0.8, a moderate mean difference; and 0.8 or greater, a large difference. The statistical analysis was conducted at a 95% confidence level, and a P value of less than 0.05 was considered as statistically significant.

3. Results

60 subjects with CAI were assessed for eligibility; eight (13.3%) were excluded due to either an injured knee ($n = 2$) or sprained ankle ($n = 3$) in the previous six months, or due to attending physical therapy for their ankle injury ($n = 3$). In total, 19 participants were assigned to the HVLA group, 18 participants to the WB-MWM group, and the remaining 15 were assigned to the placebo group. The total number of participants screened, reasons for ineligibility, and dropouts is shown in Fig. 1. All quantitative, demographic, and dependent variables had a normal distribution. There were no significant differences between groups before interventions (Table 1). Repeated measures ANOVA showed a significant effect × time ($F_{4,192} = 20.65$; $P < 0.001$; $\eta^2 = 0.30$) and a significant time × group interactions ($F_{8,192} = 6.34$; $P < 0.001$; $\eta^2 = 0.21$). Bonferroni *post hoc* analysis showed a significant increase of ankle dorsiflexion in both WB-MWM and HVLA groups with respect to the placebo group but no differences between the WB-MWM and HVLA groups (Fig. 5 and Table 2). Within-group effect sizes between pre-intervention and 48 h post-intervention for dorsiflexion were small for the HVLA group (Cohen $d = 0.44$) and moderate for the WB-MWM group (Cohen $d = 0.61$) while the placebo group had an negligible effect size ($d = -0.14$). Between-groups effect size with respect to the placebo at 48 h post-intervention was large for both the HVLA and the WB-MWM groups (Cohen *d*, 1.46 and 1.31 respectively).

4. Discussion

The findings of this investigation demonstrated that one application of manipulation or mobilization (HVLA and WB-MWM) of the talocrural joint significantly improved ankle dorsiflexion in participants with CAI. There were no significant differences between the two manual techniques over time but WB-MWM showed greater within-group effect sizes than HVLA between pre-intervention testing and two days after application. When they were compared with the placebo group, both active interventions were more effective for the improvement of dorsiflexion showing large effect sizes.

With regard to the HVLA technique, our results contradict those of Andersen et al. (2003) and Fryer et al. (2002). These authors used a single HVLA talocrural manipulation and did not find any significant improvement in dorsiflexion, however these different results are likely due to the different nature of the sample. While in our study participants had CAI, in these previous studies; the samples were composed of asymptomatic participants. Another explanation for these differences could be the application of three thrusts in our study regardless of getting an audible joint cavitation. While cavitation is usually associated with increased range of motion, Venturini et al. (2007) contends that a distraction manipulation on the ankle applied quickly in a single movement may be insufficient to provoke an adequate adaptation of the connective periarticular tissues of the joint. When this technique was used in symptomatic people, the results on ankle dorsiflexion were more likely to improve range of motion (Dananberg, Shearstone, & Guilliano, 2000; Pellow & Brantingham, 2001).

The results of the application of a WB-MWM on ankle dorsiflexion in our study were similar to previous studies (Collins et al., 2004; Vicenzino et al., 2006). Collins et al. (2004) used a crossover

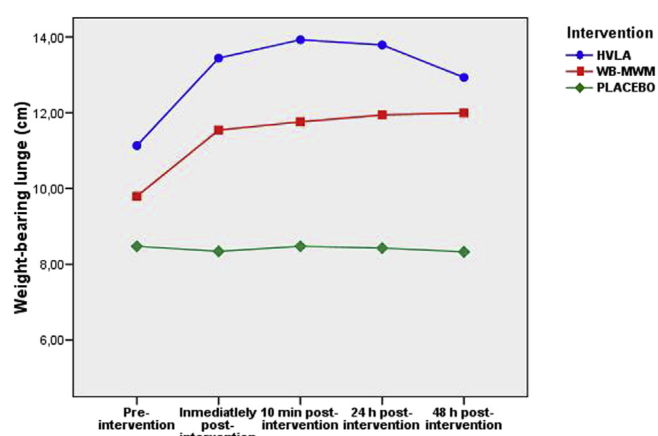

Fig. 5. Evolution of weight-bearing lunge measurement for different interventions during the period of 48 h.

Table 2
Ankle dorsiflexion in each group along time.

Group	Pre-intervention	Immediately post-intervention	10 min post-intervention	24 h post-intervention	48 h post-intervention
HVLA	11.13 ± 3.8	13.4 ± 4.1*†	13.9 ± 4.1*†	13.8 ± 3.6*†	12.9 ± 4.2*‡
MWM	9.8 ± 3.5	11.5 ± 3.8*§	11.8 ± 3.5*§	11.9 ± 3.7*‖	12 ± 3.7*§
Placebo	8.5 ± 1.4	8.3 ± 1.5	8.5 ± 1.4	8.4 ± 1.4	8.3 ± 1.5

HVLA: High velocity and low amplitude manipulation; MWM: Mobilization with movement. Values are means ± SD of weight-bearing lunge in cm. *Significantly greater than pre-intervention $P < 0.001$; †significantly greater than placebo $P < 0.001$; ‡significantly greater than placebo $P = 0.001$; §significantly greater than placebo $P < 0.05$; ‖significantly greater than placebo $P < 0.01$.

design with 14 participants with a subacute grade II ankle sprain. They used a similar WB-MWM and placebo methods to our study apart for the dosage of the mobilization where they applied three sets of 10 repetitions. The improvement of ankle dorsiflexion after the application of the technique was on average1.6 cm for the active group, which was almost identical to our result (1.7 cm). The study by Vicenzino et al. (2006) demonstrated an improvement of dorsiflexion immediately after the application of four sets of four repetitions of a WB-MWM and non-weight-bearing MWM in participants with recurrent ankle sprains; however, these results were not significantly different than the controls. The improvement of dorsiflexion was of 0.6 cm for the WB-MWM group, lower than found in our study. It is interesting to note that the participants in the study by Vicenzino et al. (2006) had a weight-bearing lunge of 4.2 cm prior to treatment while our sample had 9.8 cm. This difference might be partly explained by the measurement of wall to toe distance as we measured from the second toe to the wall.

As far as we are aware, our study is the first that has compared a mobilization with a manipulation technique on CAI participants. While Vicenzino et al. (2006) compared the efficacy of a weight-bearing and non-weight-bearing MWM, Beazell et al. (2012) compared two manipulative techniques (proximal and distal tibiofibular joint manipulation) on ankle dorsiflexion. Their results showed no differences between groups for ankle dorsiflexion after the application of the protocol. In our study, both manual techniques demonstrated similar effectiveness, however, the WB-MWM had greater effect sizes after 48 h.

The mechanism for improvement in ankle dorsiflexion using mobilization techniques is not completely understood. It is possible that with the recurrence of sprains that is often seen in CAI, a positional fault could affect joint kinematics. Denegar et al. (2002) observed an increased laxity of the talocrural joint associated with a limitation of posterior talar glide in 12 athletes with previous ankle sprains. These findings are similar to those of Vicenzino et al. (2006) noted in 16 participants with recurrent ankle sprains. The limitation of posterior talar glide may be due to an anterior displacement of the talus after a sprain (Collins et al., 2004) that may persist in people with CAI (Wikstrom & Hubbard, 2010). The antero-posterior glide component of the WB-MWM may reduce this positional fault and facilitate the restoration of posterior talar glide and ankle dorsiflexion (Vicenzino et al., 2006). The above explanations are in accordance to the concave/convex rule which states for ankle dorsiflexion that the convex talus should roll upward and slide posteriorly on the concave tibiofibular mortise (Green et al., 2001). As this current study found both HVLA and WB-MWM to be effective we suggest that it is more likely that both manual techniques influence the restoration of normal joint kinematics by the elongation of periarticular joint capsule and the improvement of accessory joint motion, as opposed to influencing any positional fault. A positional fault described by some authors (Hing, 2009; Hubbard et al., 2006; Miller, Birmingham, & Jenkyn, 2009; Mulligan, 1999; Vicenzino, 2009) is suggested to consist of an anteriorly displaced fibular malleolus however, there is limited evidence to confirm or refute the hypothesis of a fibular positional fault (Vicenzino, 2009; Vicenzino, Paungmali, & Teys, 2007). In addition, the techniques used in the present study were not oriented to correct this positional fault.

Both techniques utilized in this current study maintained dorsiflexion range for two days which is considered to enable optimization of treatment planning. Manual techniques therefore do not need to be applied daily but can be spaced at least two days apart without apparent loss of dorsiflexion range.

It is important to acknowledge limitations associated with this study. Firstly the sample size for each arm of the study was relatively small. Taking into account a confidence level of 95%, statistical power of 80% and variance in weight-bearing lunge of 1.96 cm for detecting a minimal difference of 1.5 cm, the sample size should have been 21 subjects per group. Another limitation of our study was that our follow up of two days was too short to determine the medium to long term effects of the treatment and ultimately the ideal timing for the next treatment session. Additionally we think that it may be difficult to generalize our conclusions based on the specificity of the techniques. It will be necessary to study these specific issues in more detail in future investigations. A further limitation of this study was the absence of specific outcome measures for pain sensitivity; it would be of interest to compare the hypoalgesic effects of both manual techniques in future studies.

It is always important to remember that clinical practice is most often based on rehabilitation programs that contain multiple components. In this regard our study design was effective for analyzing specific effects but not for establishing the efficacy of complete treatment paradigms.

5. Conclusion

Our results indicate that the single application of WB-MWM or HVLA manual technique improves ankle dorsiflexion in people with CAI, and the effects persist for at least two days. Both techniques have similar effectiveness for improving ankle dorsiflexion although WB-MWM demonstrated a greater effect size.

Conflict of Interest

The authors have not conflicts of interest to disclose.

Ethical Approval

The investigation obtained the approval of the Bioethics Committee of CEU-San Pablo University.

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