The Effect of Talo-Crural Joint Manipulation on Range of Motion at the Ankle Joint in Subjects with a History of Ankle Injury

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ABSTRACT

Introduction: There is little research available on the effects of peripheral joint manipulation. Only a few studies have examined the effect of manipulation on ankle range of motion, with conflicting results. This study aimed to determine whether a single high-velocity, low-amplitude (HVLA) thrust manipulation to the talocrural joint altered ankle range of motion in subjects with a history of lateral ligament sprain.

Methods: Male and female volunteers (N=52) with a history of lateral ligament sprain were randomly assigned into either an experimental group (n=26) or a control group (n=26). Those in the experimental group received a single HVLA thrust to the talo-crural joint, whilst those in the control group received no treatment intervention. Pre-test and post-test measurements of passive dorsiflexion range of motion were taken.

Results: No significant changes in dorsiflexion range of motion were detected between manipulated ankles and those of control subjects using dependent and independent t-tests. Ankles that cavitated displayed a greater mean DFR and large effect size (d=0.8) compared to those that did not gap and cavitate, but analysis with ANOVA revealed these differences to be not significant.

Conclusion: HVLA manipulation of the ankle did not increase dorsiflexion range of motion in subjects with a history of lateral ligament sprain.

Key Terms: Ankle Joint; Manipulation; Dorsiflexion; Range of Motion, Osteopathy

INTRODUCTION

Injury to the lateral ligaments of the ankle is one of the most common sporting injuries in active people.[1] These sprains account for approximately 25% of all time lost from competition.[2] The mechanism of ankle injury is predominantly one of excessive ankle inversion that occurs during landing, particularly with the foot in plantar-flexion and internal rotation.[2]

Manipulation, or high velocity, low amplitude thrust technique (HVLA), involves a sudden force or thrust that may produce cavitation of a synovial joint. During this cavitation an audible release can manifest and it is hypothesised that a gas forms within the joint space resulting in a "crack".[3] The surrounding ligaments and joint capsule are stretched, and then "snap" back, which is proposed to contribute to this perceptible release. [3]

Whilst much research has focused on the efficacy of spinal joint manipulation to increase spinal range of motion (ROM),[4,5,6] there has been a lack of research investigating cavitation of peripheral joints.[7] Spinal joints have been reported to respond positively to manipulation, with an increase in spinal joint range of motion, albeit temporarily,[4,5,6] and it is assumed that peripheral joints may respond similarly. Some peripheral joint research has investigated healthy populations[8,9] while other studies have recruited symptomatic volunteers. [10,11]

The two studies that used the most reliable measurement techniques investigated the efficacy of ankle joint manipulation on healthy populations. Nield *et al.*[8] measured dorsiflexion range of motion (DFR) at five consecutive torque levels before and after talo-crural manipulation. Twenty subjects were involved in this study, with one ankle acting as the experimental ankle (HVLA manipulation), whereas the opposite ankle received no intervention, undergoing measurement only. Pre-conditioning of the ankle joint complex was performed before the treatment intervention. It is commonly performed prior to mechanical testing of viscoelastic tissues to achieve repeatable results as it involves passively dorsi-flexing the ankle joint three times before DFR is measured. Passive DFR was measured using a procedure adapted from Moseley & Adams[12]. A photographic still was used to obtain dorsiflexion measurements. The study found no significant alteration in DFR following the talo-crural manipulation.

Fryer *et al.* [9] conducted a similar trial on asymptomatic subjects and also reported no significant increase in ankle dorsiflexion following manipulation. Unlike Nield *et al.*[8], a single standardised torque was employed when measuring ankle dorsiflexion. Each subject was marked on the base of the fifth metatarsal, the lateral malleolus and the fibula head. Pre-conditioning was performed before both pre and post measurements were taken. A Nicholas® hand-held dynamometer was used to accurately measure the examiners' applied torque and was used to maintain equal passive torque for the pre and post measurements of DFR. Still images were recorded on a digital video camera to obtain the internal angle of DF formed by the three bony landmarks, and later analysed with Swinger motion analysis software. A single longitudinal talo-crural manipulation was performed, however manipulation was found to produce no change on ankle DFR. These researchers did find that ankles with a greater pre-range DFR were more likely to 'pop' or cavitate, which suggested that ligament laxity may be a feature of ankles that easily cavitate.

Two studies investigated the effectiveness of manipulation on ankle dorsiflexion recruited symptomatic subjects.[10,11] Both of these studies reported that DFR increased significantly following manipulation on their sample populations.

Dananberg *et al.*[10] reported that the combination of two lower limb manipulations and traction had an immediate positive effect on DFR. This study recruited a small sample size (N=22) selected from a podiatry clinic on the basis of reduced DFR on initial physical examination. A mark was placed on the base of the subjects' fifth metatarsal and on the inferior tubercle of the lateral calcaneus for first arm lever of the goniometric measurement. The second arm lever was created by placing a mark on the centre of the lateral malleolus and another mark on the distal shaft of fibula. DFR was performed using 'active assisted' ROM by placing a cloth cord around the metatarsal heads. The subjects were instructed to pull the foot toward them until they reached their comfort limit. The treatment intervention included a HVLA on the proximal fibula' followed by traction of the talocrural joint for 30-45 seconds, and then a HVLA to the talocrural joint. Measurements were taken before and after manipulation in the same way.

Pellow & Brantingham[11] also examined ankle manipulation on subjects with stable subacute and chronic grade I and grade II sprains. This was a single-blind, comparative, controlled pilot study. Along with the measurement of dorsiflexion, pain and function were also assessed via questionnaire. Both control and experimental groups were treated until they were either symptom-free or had received a maximum of eight treatments over the four week period. The control group received detuned ultrasound over the ankle for a period of five minutes per treatment session. The experimental group, who received an ankle mortise separation adjustment, were treated over a four-week period. Goniometry was employed to measure ankle dorsiflexion.

The authors reported that grade I and II sprains responded positively to manipulation with an increased DFR when compared to detuned ultrasound therapy. The trial established that manipulation to injured ankles reduced pain, increased ankle range of motion, and promoted a return of ankle function when compared to detuned ultrasound therapy.

The current study aimed to determine whether talo-crural manipulation assisted in increasing DFR in subjects with a history of lateral ligament sprain, using a reliable measurement procedure.[12]

METHODOLOGY

Participants

Fifty-two healthy male (N=23) and female (N=29) volunteers participated in this study (18-34 years, mean age 22). Volunteers with a history of lateral ligament sprain were included in the study. However, ankles were not currently painful, nor was the injury recently sustained (less than six months prior). The trial used the previously injured ankle as the experimental ankle. All subjects completed consent forms for participation. The results of one participant were excluded from the study as the post-measurement image from the digital camera still was not adequately focused.

Measurement of Dorsiflexion Range of Motion (DFR)

Subjects were placed in the supine position on a Biodex table with their hip and knee flexed to 90°, and secured by Velcro over the trunk, thigh and lower leg. Researcher 1 placed the marker on the subjects' fibula head, lateral malleolus and fifth metatarsal head. Three consecutive dorsiflexion motions were applied to each ankle to 'pre-condition' it before testing.[8] A Nicholas® hand-held dynamometer (Fig 1) was used to accurately measure torque applied to the ankle for both the pre and post treatment measurements,[9] which has been shown to have high inter-rater and repeated measures reliability[12] (Fig 2).

Figure 1. Nicholas dynamometer

Figure 2. DFR measuring procedure

Researcher 1 applied three passive dorsiflexion motions to the test ankle to pre-condition it before testing. For testing, dorsiflexion to full passive range was applied and the torque value was recorded. This value was also used as the applied torque for the post-treatment measurement. A tripod-mounted Canon digital video camera located perpendicular to the subject approximately 5 metres away from the Biodex table recorded the images.

Photographic stills from the digital video camera of pre and post-tests was then analysed with Swinger motion analysis software (Version 1.26). The software was used to calculate the internal angle formed by the bony landmarks on three separate occasions. It was the average of these three measurements that was used in the statistical analysis. A simple three-point digitisation model was used.

Established by Moseley and Adams[12] and advanced by Fryer *et al.*,[9] this overall measurement procedure was found by Fryer *et al.*[9] to have a high interrater reliability; the Intraclass Correlation Coefficient for the combined group data was 0.97 and the percentage intertester agreement was 77 percent.

Procedures

Subjects were tested for DFR and then randomly assigned to either the control or experimental group by picking a card from a concealed container held by Researcher 2.

Subjects walked to a separate treatment room, where those in the experimental group received a single manipulation to the talo-crural joint by Researcher 3 (an Osteopath). Participants in the control group were simply required to lie on the treatment table for an equivalent time. All subjects returned to the testing room for post-treatment measurements, performed by Researcher 1 who again 'pre-conditioned' the ankle as for pre-test measurements. Researcher 1 was blinded to the subject's allocation into the control or experimental group.

Manipulative Intervention

A single HVLA technique to the talo-crural joint was performed by an experienced, registered Osteopath (Researcher 3). The technique was a caudal thrust, with the patient supine. The Osteopath interlaced both hands over the tibia and talus, with thumbs over the posterior aspect of the calcaneous, creating a dorsiflexion component. Distraction resulted in tension focused at the talo-crural joint, and a short thrust was applied as described by Hartman[13] (Fig. 3).

Following the HVLA, Researcher 3 judged the outcome as follows:

a) A palpable joint gap and an audible joint pop (G&P)
b) A palpable joint gap but no audible joint pop (G&NP)
c) No palpable joint gap and no audible joint pop (NG&NP)

Figure 3. Talocrural HVLA manipulation

RESULTS

Data Analysis

It was hypothesised that a difference in DFR would exist between the control group, which received no treatment intervention and the experimental group, which received a talo-crural joint manipulation. Thus a two-tailed t-test was employed in the statistical analysis.[14] All data was analysed using the SPSS Version 10.0 for Windows statistical program.

From Table 1 it can be seen that the mean torque values for the control and experimental groups in both the pre-test and post-test measurements were extremely consistent. For the control group, the mean angles both before and after treatment were slightly lower than the experimental group. The mean difference in angles between the pre and post measurements for the control and experimental group was minimal (0.18 and 0.34 degrees respectively).

No significant difference between pre and post-treatment are evident in either group (Table 2). The control group returned a p value of 0.754, and a p value of 0.707 was calculated for the experimental group. No significance was apparent (p=0.84) between the control and experimental groups when comparing the change in dorsiflexion range post intervention (Table 3).

Of the experimental sub-groups, the gap and pop (G&P) group had the smallest angle (largest DFR) (Table 4), although a one-way ANOVA showed these differences to be not significant (p=0.347). Effect size calculations showed that the differences in the

G&P and NG&NP groups produced a large effect size (*d*=0.8), whereas differences between the other two subgroups had small to medium effect sizes.

Table 1: Pre and Post Results for Control and Experimental Groups

(standard deviations)

Table 2: Paired t-test (pre – post) for Control and Experimental Groups

Table 3: Independent t-test for differences in mean change between groups

Table 4: Experimental sub-group pre-treatment DFR means

Table 5: Experimental sub-group pre-treatment DFR effect sizes (Cohen's d)

DISCUSSION

This study found that a single talocrural HVLA manipulation did not produce an increase in dorsiflexion range of motion (DFR) in subjects with a history of lateral ligament sprain. No significant difference was found between pre and post-manipulative DFR when the raw results were analysed using a dependent t-test, and mean changes were not significantly different between the experimental and control groups using an independent t-test. Therefore the hypothesis that ankle joint manipulation increased DFR in these subjects was rejected.

There appeared to be considerable variation of ROM following HVLA, evidenced by the relatively large standard deviations, with some subjects achieving greater range and others with lessened range. These results appeared to cancel each other out, as the mean change was close to zero.

Our results were consistent with Nield *et al.*[8] and Fryer *et al.*[9] who also reported no significant increases in DFR following a single HVLA manipulation. The methodology of these two studies and the current study were comparable, with the only difference being that our study used subjects with a history of lateral ligament injury.

In contrast, Dananberg *et al.*[10] and Pellow & Brantingham[11] reported large significant increases in their studies of ankle joint manipulation. There were a number of differences between the present study and those performed by Dananberg *et al.*[10] and Pellow & Brantingham.[11]

Dananberg *et al.*[10] used subjects with a mean age of forty-six years (subjects in the present study had a mean age of twenty-two) and who had a reduced DFR on initial examination. The differing results between the Dananberg *et al.*[10] study and this current one were unlikely to be attributed to the age discrepancy, but the reduced DFR on physical examination may well have played a role.

Pellow & Brantingham[11] also used symptomatic or acute subjects (those with grade 1 or 2 ankle sprains), whereas our study used subjects with only a history of ankle injury. Once again, subjects who were currently symptomatic or demonstrating reduced DFR may respond differently to those who are not symptomatic.

Measurement procedures used to evaluate the effect of manipulative intervention must be accurate and reliable. The present study used a standard body position, skin surface markers, a known torque, a standardised testing position and digital photography which has been reported to have high inter-rater reliability.[12] The two other studies that failed to demonstrate increases in DFR following manipulation also used a similar procedure.

Dananberg *et al.*[10] and Pellow & Brantingham[11] used a different procedure for measuring DFR. Both used an extended knee when testing for ankle DFR, instead of flexing the knee where tension would be taken off the triceps surae muscle group for a better indication of ankle dorsiflexion range. Further, a known torque was crucial to measurement repeatability, as an exponential relationship exists between torque and angular displacement of passive ankle dorsiflexion.[12] If an unknown level of force were exerted on the ankle at an unknown distance from the centre of rotation, variation of measurement may result. It has been established that photography significantly increased accuracy of measurement compared to a goniometric method.[15] Dananberg *et al.*[10] and Pellow & Brantingham,[11] however, both used goniometry to analyse DFR measurements. For these reasons, the measurements by Dananberg *et al.*[10] and Pellow & Brantingham,[11] who used an extended knee and did not standardise torque, were likely to be less reliable than those of the current study.

The methodology used by Dananberg *et al.*[10] appeared subject to further error. DFR was performed as an 'active assisted' movement, where subjects used a cloth cord to dorsiflex their ankles to 'comfort limit'. Enthusiastic subjects may have pulled harder on the post-treatment measurement, potentially resulting in the significant increases this study yielded.

The treatment interventions used by Dananberg *et al.*[10] and Pellow & Brantingham[11] differed from the present study. Pellow & Brantingham[11] performed multiple ankle mortise separation adjustments for the experimental group over a four-week period. This differed from the single talo-crural HVLA that our study performed may have contributed to the different results between these studies.

Dananberg *et al.*[10] used two manipulations (talocrural and superior tibio-fibula) and sustained ankle traction. It should not be assumed that a single ankle HVLA technique would reproduce these results. This sustained traction may have produced viscoelastic changes in the ankle ligaments and triceps surae musculature, and been more effective than a single HVLA in producing increased DFR. The authors compared these results to a Grady and Saxena report[16] on the efficacy of stretching techniques on ankle dorsiflexion. Comparatively, two manipulations and traction resulted in nearly twice as much improvement as that demonstrated by the subjects in the stretching trial, and as previously stated, the increased dorsiflexion range was experienced instantaneously.

When contrasting the current study to the Fryer *et al.*[8] study, it is interesting that six out of twenty-six ankles in the current study gave a 'pop' or cavitated (23%), compared to the study of Fryer *et al.*[8] where 32% of the ankles cavitated. This implies that a previously injured ankle is more difficult to produce the desired cavitation, as the same osteopath performed the interventions in both studies. It may be feasible that a previously injured ankle has pre-stressed the joint capsule such that a cavitation and significant change in ROM is difficult to achieve.

Fryer *et al.*[8] found that those ankles that cavitated had a significantly greater pre-intervention range of DFR, suggesting that a certain amount of ligamentous laxity may make the joint easier to cavitate. The present study also found the cavitating G&P group to have the greatest pre-test mean DFR, however, the differences between the experimental sub-groups were revealed to be not significant. Given the small numbers involved, and consequent low power to detect significant change, effect sizes were calculated for the sub-groups. The difference between the G&P and NG&NP groups demonstrated a large effect size (d=0.8), and suggest that, as in the Fryer *et al.*[8] study, ankles that cavitated tended to have a greater DFR.

Whilst our results showed that manipulation did not significantly increase DFR for subjects with a history of lateral ligament sprain, increased range may not necessarily be a desirable therapeutic outcome. It is possible that a more mobile joint may not actually assist the patient is any way. It may be possible that manipulation could influence ankle proprioception and stability, rather than ROM, as appears to be the case with spinal manipulation.[17,18] Proprioception is often the first step in rehabilitation following injury to the lateral ankle ligaments for most health care providers, and assessment of this following manipulation may yield results.

CONCLUSION

This study found that a single HVLA manipulative intervention to the talocrural joint in subjects with a history of lateral ligament injury did not significantly alter dorsiflexion range of motion compared to non-manipulated ankles. This suggests that talocrural joints and spinal joints may respond differently to manipulative intervention.

SUMMARY OF IMPORTANT POINTS

- Only a few studies have examined the effect of manipulation on ankle range of motion, with conflicting results.
- This study aimed to determine whether a single high-velocity, low-amplitude thrust manipulation to the talocrural joint altered ankle range of motion in subjects with a history of lateral ligament sprain.
- No significant changes in dorsiflexion range of motion were detected between manipulated ankles and those of control subjects using dependent and independent t-tests.
- Ankles that cavitated displayed a greater mean DFR and large effect size (d=0.8) compared to those that did not gap and cavitate, but analysis with ANOVA revealed these differences to be not significant.
- Manipulation of the ankle did not increase dorsiflexion range of motion in subjects with a history of lateral ligament sprain.

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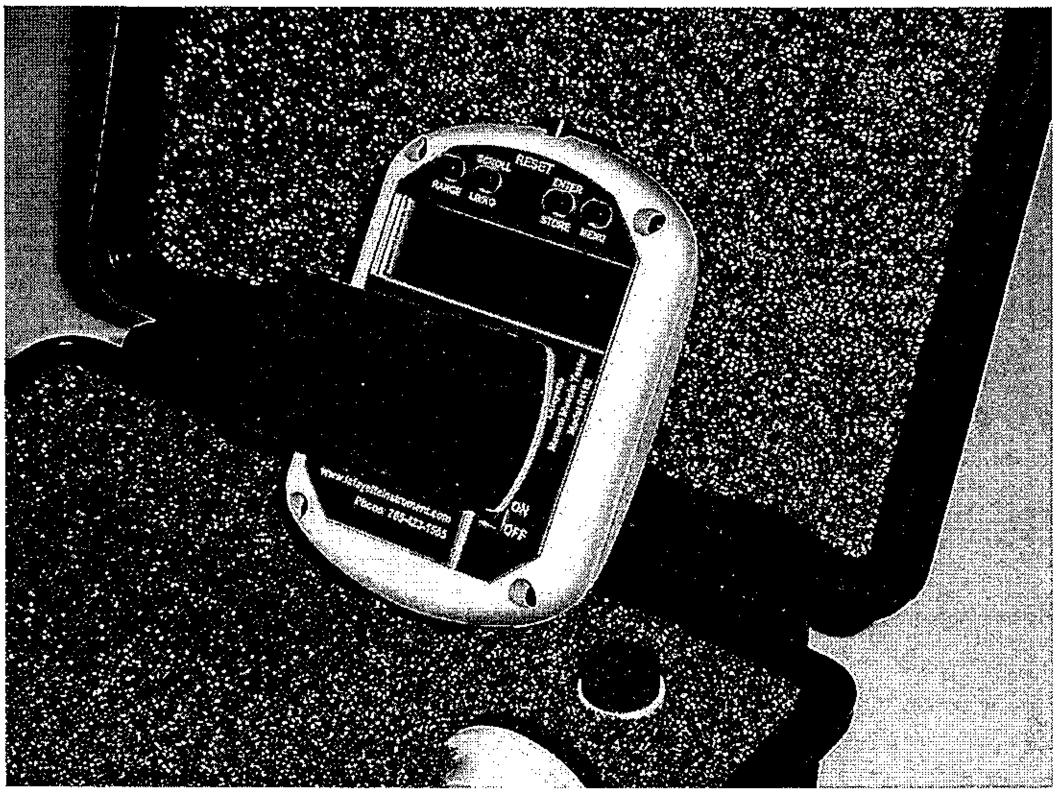

Figure 1. Nicholas dynamometer

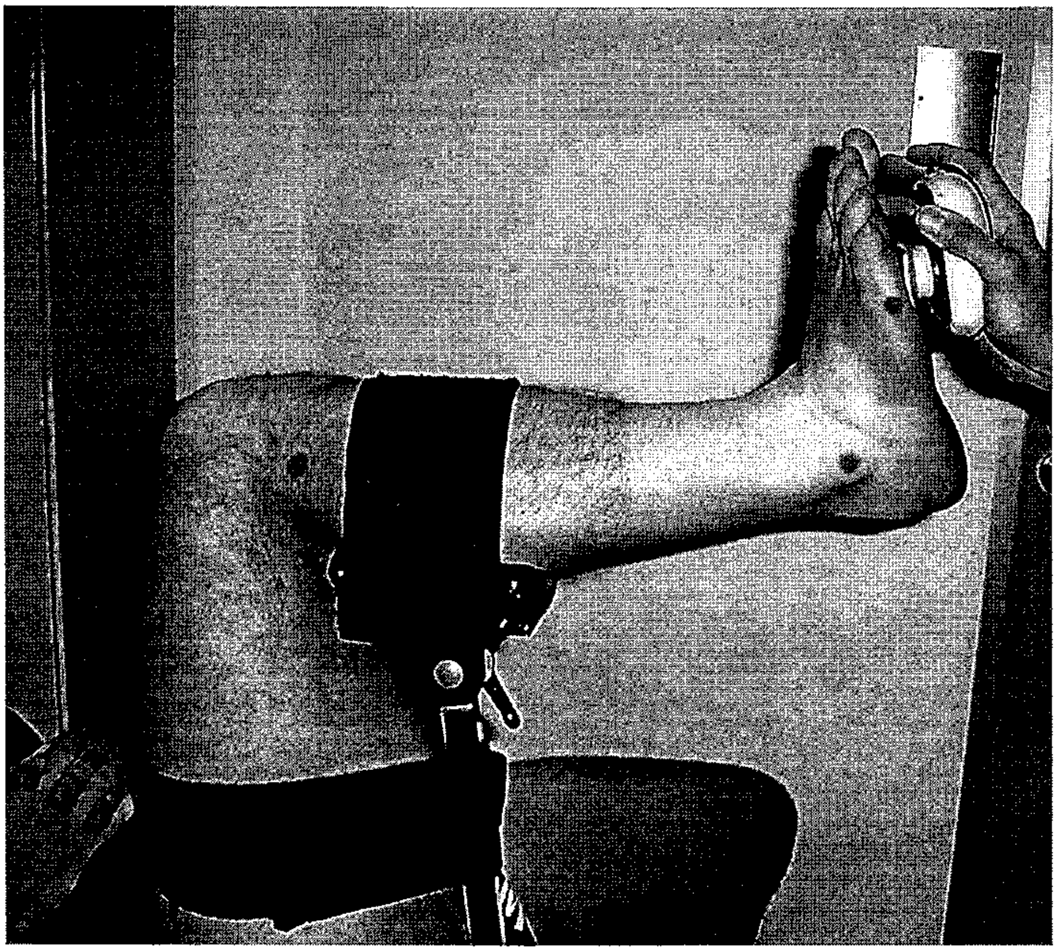

Figure 2. DFR measuring procedure

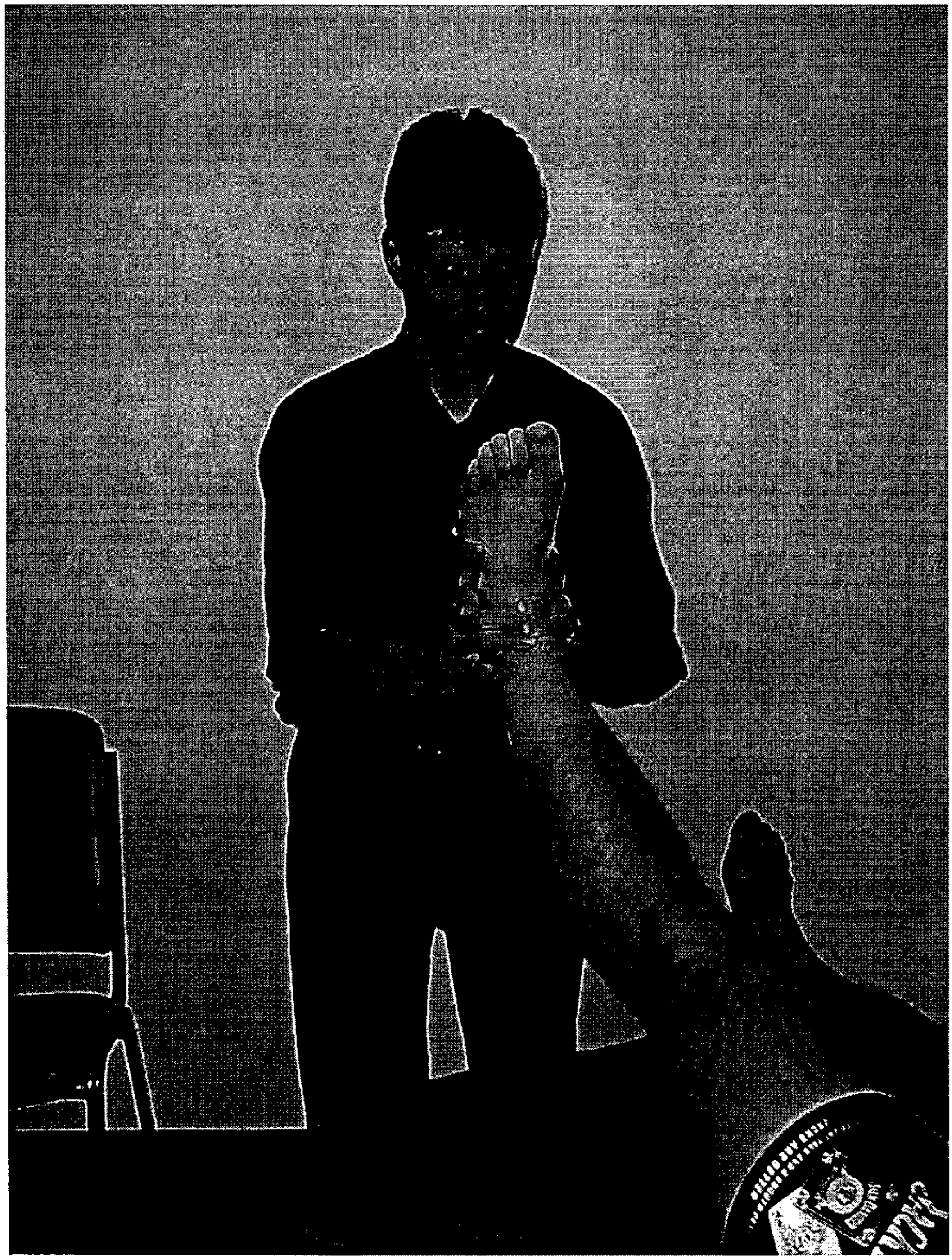

Figure 3. Talocrural HVLA manipulation

		Pre - test		post - test		Mean diff
Group	N	Mean torque	Mean angles	Mean torque	Mean angles	(degrees) pre - post
Control	25	10.4 (2.1)	96.1 (5.5)	10.5 (2.1)	96.3 (6.4)	0.18 (2.2)
Experimental	26	10.4 (1.7)	97.8 (6.2)	10.5 (1.7)	98.2 (6.4)	0.34 (3.1)

Table 1: Pre and Post Results for Control and Experimental Groups

(standard deviations)

	t value	Signifance (p)
Control	-0.317	0.75
Experimental	-0.381	0.71

Table 2: Paired t-test (pre – post) for Control and Experimental Groups

Group	N	Mean diff	Std. Deviation	t	Sig.
Experimental	26	0.34	3.1	0.21	0.84
Control	25	0.18	2.2		

Table 3: Independent t-test for differences in mean change between groups

	N	Mean	Std Dev
G&P	6	95.02	6.60
G&NP	12	97.82	5.85
NG&NP	8	99.99	6.39
Total	26	97.84	6.21

Table 4: Experimental sub-group pre-treatment DFR means

Sub-groups	Mean diff	Effect size
GP – GNP	2.80	0.45
GP – NGNP	4.97	0.80
GNP – NGNP	2.17	0.35

Table 5: Experimental sub-group pre-treatment DFR effect sizes (Cohen's *d*)