THE EFFECT OF MANIPULATION TO THE PROXIMAL TIBIOFIBULAR JOINT AND TALOCRURAL JOINT ON ANKLE DORSIFLEXION RANGE OF MOTION.

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ABSTRACT

Background: Peripheral joint manipulation is an intervention used by manual therapists for a wide array of musculoskeletal problems. There is conflicting evidence on the effect of manipulations on passive ankle dorsiflexion range of motion (DFR).

Objective: To determine whether a manual treatment protocol increases passive ankle DFR.

Design: A randomised controlled and single blinded study

Subjects: Asymptomatic male and female volunteers (N=60)

Methods: Participants were randomly assigned into the experimental group (n=32) or the control group (n=28). Subjects in the experimental group had HVLA manipulation performed on their right proximal tibiofibular joint, talocrural joint and 30 seconds of talocrural joint tractions while those in the control group had no treatment.

Results: No significant difference in DFR was found in the experimental group between pre and post intervention (p=0.66). Participants whose tibiofibular joint and talocrural joint manipulated with an audible sound showed a trend towards a greater range of dorsiflexion pre-intervention (d=1.09).

Conclusions: A treatment regimen of manipulation of the proximal tibiofibular joints and talocrural joints and traction of the talocrural joint in asymptomatic patients was not effective in increasing ankle dorsiflexion range of motion.

Key indexing terms: dorsiflexion, talocrural joint, proximal tibiofibular joint, manipulation.

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Introduction

Manipulation is a therapeutic technique employed by many manual therapists that has been demonstrated to increase range of motion,[1,2] improve proprioception[3] and decrease pain[4] in spinal joints. High Velocity Low Amplitude (HVLA) thrust manipulation involves applying a quick controlled force through a synovial joint in order to produce cavitation and increase range of motion (ROM).[5] This type of manipulation is usually associated with an audible "crack" or "pop".[6] The importance of the audible cavitation to the success of the treatment is contentious. Research has shown that an audible noise has no influence on the improvement of range of motion (ROM), pain or disability when performed on the sacroiliac joint.[7]

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Spinal manipulation has been demonstrated to produce an increase in range of motion, particularly in the cervical spine. Whittingham *et al.*[1] conducted a double blind randomized controlled trial on subjects (N=105) with cervicogenic headaches and found a significant increase in ROM in the cervical spine following manipulation. Other randomized controlled studies have also showed an increased ROM after cervical spine manipulation.[2,4]

Manipulation is not confined to spinal joints and many authors have described manipulative techniques that can be applied to peripheral joints.[8,9,10] Research surrounding peripheral manipulation however is far less extensive than the volume of literature encompassing spinal manipulation. While the mode of action for spinal manipulation is purported to be due to either intra-articular or neurophysiologic effects,[11] the mechanism of peripheral manipulation is unclear. Menz[12] suggested that the change brought about by adjustive techniques may effect altered afferent feedback resulting in a reduction of symptoms. Some authors[13,14] believe peripheral manipulation may break down collagen cross-linkages which develop in the presence of immobilization or disuse, and manipulation may therefore result in an increased ROM.

Research surrounding manipulation of the ankle joints has produced conflicting results and therefore its effectiveness remains unclear. The majority of research on peripheral joint manipulation has involved the ankle joint, of which only two studies have shown potentially beneficial effects of such treatment.[15,16]

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Nield *et al.*[17], Fryer *et al.*[18] and Anderson *et al.*[19] each examined the effect of a single caudad thrust to the talocrural joint and used similar measuring procedures found no significant change in DFR. The measuring procedure employed by these authors was adapted from Moseley and Adams. [20] Nield *et al*[17] produced a high test-restest reliability with an intraclass correlation coefficient value of .97. Fryer *et al* [18]used twenty repeated measures which were assessed by 20 separate testers to again produce a high reliability (r[21,2]=0.95). In each of these three studies,[17,18,19] the researchers applied a constant pre-post torque to the foot and employed photographic analysis to measure the internal angle formed by the fifth metatarsal head, the lateral malleolus and the proximal fibular head to determine DFR.

Nield *et al.*[17] assessed the effect of talocrural joint (TCJ) HVLA manipulation on ankle dorsiflexion range of motion (DFR) using asymptomatic subjects (N=20). Measurements were taken pre and post manipulation using five consecutive torque levels, and photographic stills were used to measure DFR. While no significant change in DFR was found, a strong relationship between applied torque and angular displacement at varying torque levels was evident. This suggests that using a constant torque is more reliable than an end of range to measure ankle DFR given dorsiflexion angular displacement is dependant of the amount of torque applied.

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Fryer *et al.*[18] performed a similar study with asymptomatic subjects (N=41). Those in the experiment group had both ankles manipulated using a single HVLA to the talocrural joint. Fryer *et al.*[18] measured ankle dorsiflexion using a standardized force, photographic stills and video analysis software. The photographic stills were taken to analyse the degree of ankle DFR pre and post manipulation while a constant torque was applied. There was found to be no statistically significant change in DFR at the ankle joint. They did find, however, that those ankles which produced an audible 'pop' or cavitation had a greater pre-test DFR, which suggested that ligamentous laxity may make the ankle more likely to cavitate.

In a more recent study, Anderson *et al.*[19] tested manipulation on participants with preexisting ankle injuries. Anderson et al. reasoned that a history of trauma may disturb joint function and reduce DFR, subsequently the previously injured ankle may respond with increased range following HVLA. Using the same measuring methods as Fryer *et al.*,[18] Anderson *et al.*[19] also found that ankle dorsiflexion was not increased by manipulation in these subjects.

In contrast to these studies which found no change in DFR, Pellow and Brantingham[16] and Dananberg *et al.*[15] reported that manipulation of the talocrural joint significantly increased ankle DFR. However the intervention protocols and measurement procedures were vastly different to those employed by Nield *et al.*[17], Fryer *et al.*[18] and Anderson *et al.*[19]

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Pellow and Brantingham[16] examined the effect of ankle HVLA manipulation over a period of 4 weeks with a total of 8 treatments on subjects with grade 1 or 2 ankle sprains (n=15). Subjects were evaluated at their first and last treatments with a 1 month follow up by subjective scores from the short form McGill Pain Questionnaire and the Numerical Pain Rating scale 101. Ankle DFR was measured using a goniometer, a pressure algometer was used to measure pain over the lateral ankle ligaments and function was also measured using a functional evaluation scoring program.[21] The protocol of the functional evaluation scoring program devised by Kaikkonen *et al.*[21] consisted of questionnaires and functional, balance and strength testing. Each test showed excellent reproducibility when tested with a reference group of 100 uninjured persons. Pellow and

Brantingham[16] found a significant improvement with respect to pain, increased ankle (ROM) and ankle function. A comparison between this and other studies is difficult given the multiple applications of the treatment intervention, the time frame over which it was applied and the numerous outcome measurements.

Dananberg *et al.*[15] examined the effect of manipulation on both the talocrural joint (TCJ) combined with the proximal tibiofibular joint (PTFJ) and sustained ankle traction. Twenty-two subjects aged between twenty to sixty nine years were recruited from a podiatry clinic based on gastrocnemius type ankle equinus i.e. an inability to achieve 10° or ankle DFR. After the intervention a statistically significant increase in ankle DFR was found in both the left (4.9° , $p<0.001$) and right (5.17° , $p<0.001$) ankles. However measurement relied on the patient pulling on a cloth band wrapped around the metatarsal heads until they reached their comfort limit. The accuracy of such measurements must be questioned given the variability that would exist with such a task. Dananberg *et al.*[15] also used a goniometer to measure ankle DFR, a measuring method which has since been shown to be responsible for considerable error.[22] Furthermore subjects may have unwittingly applied more force to show an apparent increase in ankle DFR. Dananberg *et al*.[15] also lacked a control group and therefore failed to account for any factors, other than treatment, that could have influenced the outcome of the results.

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Dananberg *et al.*[15] claimed that the failure of translation of the fibula is the precipitating factor in a wide range of ankle pathologies and as such can be successfully treated with manipulation of the superior tibiofibular joint. Movement of the fibula can occur in many directions and according to Johnson *et al.*[23] the degree and direction of movement is dependant on the orientation of the proximal tibiofibular facet. Eichenblat *et al.*[24] claimed facets with a more vertical orientation display the greatest joint mobility. Considering the proposed impact of the PTFJ on the ankle a treatment technique directed at correcting dysfunction of this joint was included in the present study.

Considering the methods used by Pellow and Brantingham[16] and Dananberg *et al.*[15] to measure DFR have questionable reliability and validity for this purpose, their reports of increased DFR following manipulative intervention is also questionable. The present study aimed to examine the novel treatment protocol used by Dananberg *et al.*[15] but measure DFR using a more reliable method, and include the addition of a control group, examiner blinding and randomized participant allocation. By making these changes the authors hope to identify whether the novel treatment protocol described by Danaberg *et al.*[15] to produce a significant increase in ankle DFR, was more effective than a single thrust to the talocrural joint which has been found not to increase DFR.

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METHOD

Participants

Sixty-one healthy male (n=20) and female (n=41) volunteers participated in this study (age range 18-31 years, mean=23±2.3). Volunteers with ankle pain, recent ankle trauma (<3months) or gross ankle instability were excluded from the study. All participants completed consent forms after having been given a written and verbal explanation of the procedures involved. One participant was excluded during DFR measurement because the markings denoting surface anatomy were not adequate for data collection. The study was granted ethical approval by the Victoria University Human Research Ethics Committee.

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Measurement of dorsiflexion range of motion

Before measuring DFR, a marker was used to distinguish three bony surface landmarks; the lateral malleolus, fibular head and base of the 5th metatarsal. Participants lay supine on a Biodex table with their hip and knee flexed at 90º, stabilised by Velcro straps across the abdomen, thigh and lower leg (Fig. 1). The ankle was then preconditioned using repeated passive end of range ankle dorsiflexion, a procedure described by Nield *et al.*,[17] in order to account for short term visco-elastic tissue change and achieve more repeatable results.

Insert Fig 1.

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A Nicholas® handheld dynamometer was used to measure torque applied during DFR measurements. The dynamometer was placed against the head of the first metatarsal and pushed until full passive dorsiflexion range was perceived by the Tester. The torque value was recorded for each individual so that the same amount of torque could be applied for the post treatment measurement. A tripod mounted Canon digital video camera located perpendicular to the subject approximately 3 metres away from the Biodex table was used to photograph the ankle in end of range passive dorsiflexion. Photographic stills of the ankle pre and post-treatment were analysed by comparing the internal angle formed by three bony landmarks. The landmarks were located using the cursor to identify the centre of the surface markings. Swinger analysis software (Version 1.27) was used to calculate the internal angle.

Procedures

Participants had their ankle DFR measured in a room with Tester 1. Once this was completed they were guided to another room where Tester 2 assigned them into either control or experimental groups by random lottery draw. Those in the control group were asked to lie on the table for 30 seconds so that Tester 1 would not become aware of which group they were assigned to by returning early for re-measurement.

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The experimental group received three treatment techniques from Tester 2 (an experienced registered osteopath) similar to the intervention described by Dananberg *et al.*.[15] The first was a HVLA thrust to the PTFJ, followed by traction to the TCJ for 10 seconds, and finally a HVLA thrust to the TCJ. Subjects then returned to Tester 1 who was blinded to which group they were assigned. Tester 1 again 'pre-conditioned' the ankle and measured ankle DFR in the same manner as before.

Manipulative intervention

1. With the patient lying supine the practitioner placed his hand under the tibiofibular joint so the 2nd proximal interphalangeal joint was directly posterior to the joint being manipulated. External rotation of the foot was added followed

by a flexion thrust to move the fibula head anterior[9](Fig 2).

2. Sustained ankle traction was then used for 10 seconds as this was part of treatment incorporated into the Dananberg *et al.*[15] study. The practitioner clasped the ankle with his fingers crossed over the dorsum of the foot and produced traction by leaning away from the foot separating the talar dome from the distal tibia.
3. A thrust to the TCJ was performed with the participant remaining supine. The osteopath wrapped both hands around the foot so his fingers were interlocked on the dorsal surface of the foot. The foot was dorsiflexed to allow the talus to move with the rest of the foot out of the talar dome by a caudad thrust with a dorsiflexion vector.[8] (Fig 3)

The manipulative intervention was recorded as either an audible manipulation (pop) or a non audible manipulation (no pop).

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Insert Fig 2 **Insert Fig 3**

Statistical methods

Statistical analysis was performed by SPSS for Windows version 12.0. The following statistical methods were used for their simplicity and ready interpretability by the osteopathic profession.

T-tests where used to determine whether one group differed significantly from another. Analysis of change within the control and experimental groups was conducted using a paired samples t-tests. Comparison between the control and experimental groups was made using an independent t-test with change scores, thus accounting for any difference at baseline. The change scores were calculated by subtracting the pre-intervention DFR from the post-intervention DFR.

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Considering several comparisons have been made the risk of a Type I error is increased. To avoid making a Type I error a Bonferroni correction of the significance (alpha) level was made to 0.017 by dividing the significance level (0.05) by the number of planned comparisons.

The present study also investigated the association between an audible cavitation and the change in ROM. Using a Point biserial correlation the change in ROM (in degrees) was compared against the type of cavitation i.e. audible or non-audible. Correlation (r) can range from -1 to +1 depending on whether a positive or negative correlation exists.

Finally a comparison between joints that produced an audible cavitation and those that did not. Within the experiment group 3 subgroups were made depending on whether an audible cavitation was produced by the PTFJ only, the TCJ only or in both the PTFJ and the TCJ. This was used to determine whether joints that have a limited ROM are more likely to produce an audible cavitation. Change scores were used as a measure of effect size with conventions based on a study by Baggett *et al.*,[25] who found the normal range non-weight bearing for ankle joint dorsiflexion is between 0°-16.5° of dorsiflexion. Magee[26] also believes that the ankle should actively dorsiflex 10° for normal locomotion. Conventions were therefore as follows: small 0.05°, medium 5.0° and large >10°.

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RESULTS

Table 1 details the pre and post differences in the two groups, as well as in the experimental subgroups, determined by the presence of an audible manipulation. From this table it is apparent that there was very little change within either group between pre and post intervention.

Analysis of within group change of DFR demonstrated no significant change in the experimental (t=-0.44, p=0.67) or the control (t=-1.81, p=0.08) groups. Comparison between the control and experimental groups also showed no significant difference in DFR (t=-0.659, p=0.51).

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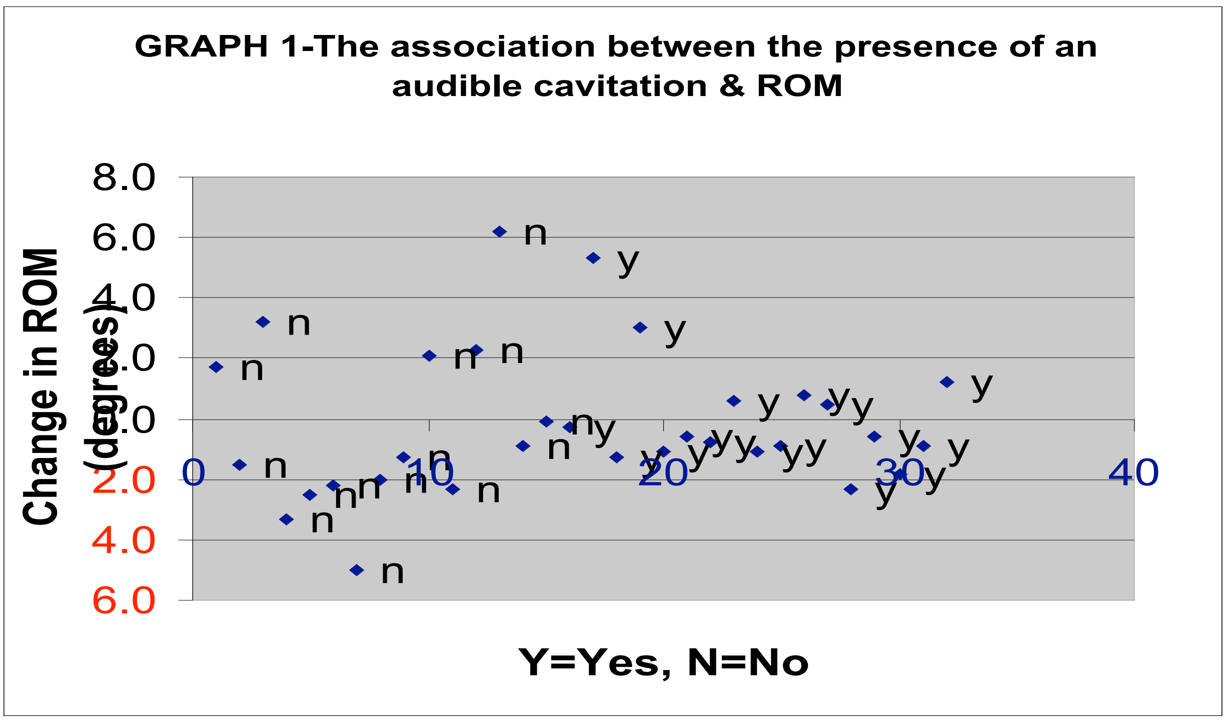
Graph 1 shows that no correlation exists between an audible cavitation and a change in ROM. A weak negative correlation was found (r =-0.07).

The effect size between the subgroups was based on the mean difference calculated from the change scores of the subgroups in degrees of DFR. As Table 2 shows, the comparison of the sub-groups “Both joints” and “No pop” produced a medium effect size (7.56°) whereas comparison between other groups produced only small effect sizes. Considering a minimum of 10° DFR is required for normal gait[26] any intervention producing a change in ROM close to this magnitude must be of a medium effect. Any intervention producing greater than 10° of DFR would be considered a large effect given normal ankle DFR can exceed 15°.[25]

Table 1: Comparison of DFR means between experimental subgroups & control group in degrees				
Group	**N**	**Pre-Test (SD)**	**Post-Test(SD)**	**Difference**
Control	28	116.08(6.54)	116.95 (6.34)	0.87
Experiment	32	116.08 (6.79)	116.26 (6.82)	0.18
PTFJ pop	8	118.58 (7.18)	117.99 (8.13)	0.59
TCJ pop	6	116.48 (5.66)	117.08 (6.57)	0.60
Both joints pop	3	108.53 (3.61)	109.03 (2.28)	0.50
Neither joint pop	15	116.09 (6.86)	116.08 (6.87)	0.01

PTFJ-Proximal tibiofibular joint, TCJ-Talocrural joint



PTFJ-Proximal ibiofibular joint, TCJ-Talocrural joint

Table 2:Comparison of pre DFR between experimental subgroups	
Sub-groups	**mean diff (°DFR)**
TCJ V No pop	0.39
PTFJ V Nopop	2.50
Both joints V Nopop	7.56

Discussion

This study showed that a manipulative intervention protocol that had previously been reported to increase passive DFR[15] had no significant effect on DFR in asymptomatic participants. The mean pre-post differences for both the control and experimental groups were less than 1º of DFR. The results are consistent with previous studies on ankle manipulation from Nield *et al.*,[17] Fryer *et al.*[18] and Anderson *et al.*,[19] who all reported no significant change in ankle DFR following HVLA intervention. In addition to the manipulation of the talocrural joint performed in these studies, the application of ankle traction and manipulation of the PTFJ did not effect ankle DFR as previously suggested by Dananberg *et al.*[15]

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Subjects who produced an audible pop in both joints had a greater pre-test mean DFR, and although this difference was not significant, a medium effect size (7.56°) when compared with joints that did not produce an audible pop. This suggests that range of motion pre-intervention may have an influence on audible cavitation. Fryer *et al.*[18] and Anderson *et al.*[19] also found that ankles that cavitated had a significantly greater pre-intervention DFR and suggested cavitation is more likely to occur in ankles with an apparent ligament laxity.

Brodeur[6] proposed the audible cavitation associated with manipulation is generated by the elastic recoil of the synovial capsule “snapping back”. The ligament laxity that Fryer *et al.*[18] suggested is present in ankles which produce an audible cavitation may account for such a mechanism. The speed of manipulation which has been shown to have an effect on the audible crack in spinal joints,[27] may also be more attainable in peripheral joints with such laxity. Comparisons between spinal manipulation and peripheral manipulation should be made tentatively considering the obvious difference in the structure and function of these joints.

Dananberg *et al.*[15] reported large increases (mean DFR=5º) following the same manipulation protocol as used in the present study. The subjects recruited by Dananberg *et al.*[15] were included on the basis of gastrocnemius type ankle equinus, defined by a limitation of ankle dorsiflexion range of 10° of motion or less when the knee was extended. According to Baggett *et al.*,[25] the normal range non-weight bearing for ankle joint dorsiflexion is between 0°-16.5° of dorsiflexion. D’Amico[28] also found that only 5° of dorsiflexion is necessary for normal gait. In light of such research ankle equinus seems clinically irrelevant given normal gait can occur in the presence of such a restriction. It may however account for the large increases in DFR achieved by Dananberg *et al*.[15] based on the theory that peripheral manipulation breaks down collagen cross linkages in the presence of immobilisation[13,14].

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Pellow and Brantingham[16] and Dananberg *et al.*[15] measured ankle DFR in the knee straight position with a goniometer and did not measure the torque applied to the ankle. Both authors reported increases in ankle DFR post manipulation. Furthermore the tester in the Pellow and Brantingham[16] study applied a passive force into dorsiflexion and was not blinded, raising the likelihood of tester bias in the application of force post-intervention. The standardization of torque in the present study combined with the blinding of the Tester measuring ankle dorsiflexion may have accounted for errors that have in previous studies possibly produced misguiding results. This may explain the deficiency of the intervention used by this study in producing a significant change in ankle DFR.

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According to Levangie *et al.*[29] dorsiflexion is more limited with knee extension than with knee flexion owing to the active tension put on the muscle. Rienmann *et al.*[30] also found that the ankle joint had significantly more stiffness when measured in the knee straight position, compared to the knee bent and concluded that the gastrocnemius muscle contributes significantly to passive ankle joint complex stiffness in this position. Because ankle DFR is limited by tension in the triceps surae, the validity of the procedure as a true measure of DFR is questionable. The studies by Nield *et al.*,[17] Fryer *et al.*,[18] Anderson *et al.*[19] and the present study have all positioned the knee in 90° flexion used constant torque for pre and post DFR measurement, for accurate and reliable measurement. It is feasible, the increases reported by Dananberg *et al.*[15] were a result of triceps muscle stretching given the position it was measured in, rather than a change in DFR due to manipulation.

The research surrounding peripheral manipulation fails to provide any foundation for its application to the ankle. Fryer *et al*[18] has shown that a restricted talocrural joint is not as likely to produce an audible cavitation with manipulation as a joint which has no apparent restriction. The present study has shown that manipulation does not significantly increase ROM regardless of the association with an audible pop. The neuropeptide release that is specific to spinal joint manipulation[11] may account for the inability of studies researching peripheral manipulation to produce results similar to those on spinal manipulation . The value of peripheral manipulation in restoring balance, increasing joint range of motion and quality of movement may simply be unachievable expectations of an enthusiastic manual therapist.

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Limitations

Moseley and Adams[20] developed a procedure to reliably measure passive ankle dorsiflexion movement in the clinical setting. This procedure was shown to be highly reliable (ICC =0.97).[20] A modification of this procedure used by Nield *et al.*[17] also produced a high reliability (r = 0.97). Fryer *et al.*[18] also examined the reliability of examiners to calculate DFR from digital stills using computer software, as was used in the present study, and reported high inter-rater reliability (r = 0.95).

The measuring procedure used in the present study was identical to that used by Fryer *et al.*[18] an intra-rater reliability study was not performed and therefore the reliability of the measuring procedure was not determined. In view of this, the conclusions of this study must be viewed with some caution.

Recommendations.

Outcome measures other than ROM assessment must be considered given ankle DFR has been shown to be unchanged following ankle manipulation. The recruitment of symptomatic subjects, combined with outcome measures such as pain questionnaires like those used by Pellow and Brantingham,[16] could also give a broader representation of the effects TCJ and PTFJ manipulation. A functional assessment such as that proposed by Kaikkonen *et al.*[21] may be a better representation of the clinical application of peripheral manipulation as opposed to ankle ROM.

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Pellow and Brantingham[16] also showed multiple interventions produced significant change in ankle function, ROM and pain reduction however their measuring procedure was questionable. The application of multiple interventions using the treatment regimen and measuring methods in the present study is another direction for further research.

In the present study, an audible manipulation of the TCJ together with the PTFJ occurred only 3 times, and so a larger experimental group may be useful in gaining a better understanding to the usefulness of the relationship of cavitation to DFR.

Proprioception is another variable that may be influenced by TCJ or PTFJ manipulation. Commonly deficient in those with ankle injuries,[31] improvement of proprioception is often the first step used for rehabilitation of the ankle joint.[32] Considering spinal manipulation has been shown to effect proprioception,[3] assessment of the effect of peripheral manipulation on proprioception is warranted.

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Conclusion

In attempt to reproduce the findings by Dananberg *et al.*[15] with the addition of a control group and more accurate and objective dorsiflexion range of motion measuring procedures, the present study found that the intervention was not able to significantly increase ankle joint range of motion. Neither of the talocrural joint or proximal tibiofibular joint manipulations combined with talocrural joint traction had any significant effect on ankle dorsiflexion range of motion.

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