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Abstract

One of the key movements available at the ankle joint is dorsiflexion (DF), which is necessary walking and running. The study presents the concept of Voodoo flossing or 'tack and floss' as an emerging alternative method of increasing DF ROM. Participants (*n* = 10; 5 Male) height (cm); mass (kg); age (years): 171.4cm ± 11.52cm, 72kg ± 8.94kg and 23.8yrs ± 4.66yrs. DF ROM was measured in full weight-bearing (FWB) using a standard anatomical tape measure placed on the floor. All participants were unable to reach 10cm of FWB DF in both ankles. Participants completed 150 seconds of voodoo flossing. FWB DF was reassessed at 0 hours following treatment and 7 hours following treatment. Right leg mean changes

in DF were calculated at 1.2cm (90% CI 0.5cm-1.8cm) which was considered a possibly moderate sized effect and from pre-test to post-test 0 hours and 0.9cm (90%CI 0.5cm-1.2cm) which was considered a possibly moderate effect. Left leg mean DF change was calculated at 1.9cm (90%CI 1.7cm-2.1cm) between pre-test and 0 hours post-test which was considered a most likely moderate sized effect and 0.1cm (90%CI 0.0cm-0.2cm) was considered trivial. The current research supports the use of Voodoo flossing as a means of increasing ankle DF based on the sample used.

Introduction

Given the number of bones, articulations and supporting ligamentous structures, the human foot and ankle is arguably one of the most complex areas of the musculoskeletal system (Whiting & Zernicke, 2008). One of the key movements available at the ankle joint is dorsiflexion (DF), which is necessary for many activities of daily living (ADL), such as walking and sitting down on the toilet (Cosby & Grindstaff, 2012). There are also further suggestions made by the likes of Fong, Blackburn, Norcross, McGarth and Padua (2011) that restricted ankle DF is associated with greater ground reaction forces during landing mechanics, restricted knee flexion displacement during landing mechanics and greater knee valgus displacement during landing and squatting tasks; all of which may contribute to increased anterior cruciate ligament (ACL) injury risk.

It is thought that a minimum of 10° of DF is required for a normal running gait during the mid-stance and toe-off phases. It is also suggested that greater DF range of motion (ROM) of between 20°-30° is required for descending stairs, and sporting activities such as squatting of setting up in blocks for a sprint (Tabrizi, McIntyre, Quesnel and Howard, 2000).

With the ankle playing such a crucial role in lower-limb mechanics and authors suggesting such strong relationships between a lack of ankle DF ROM and lateral ankle ligament injuries; it is no wonder that many therapists strive to provide effective therapeutic interventions for increasing ankle DF ROM (Terada, Pietrosimone and Gribble, 2013).

The current study looks to review some of the existing recommendations in the field of enhancing DF ROM and the supporting evidence. The study presents the concept of Voodoo flossing or 'tack and floss' as an emerging treatment and presents supporting evidence for the use such a treatment as an alternative method of increasing DF ROM.

Literature Review

One therapeutic modality for increasing ankle DF ROM, suggested within the literature, is the use of stretching of the triceps surae muscle group (gastrocnemius and soleus), along with the Achilles tendon. Radford, Burns, Buchbinder, Landorf and Cook (2006) conducted a systematic review of literature relating to the use of stretching for the triceps surae group in order to increase ankle DF. The systematic review by Radford *et al* (2006), did find that stretching can bring about small, but statistically significant, increases in DF ROM. However, of the 5 trials which met the inclusion criteria, none shared the same method of stretching. For instance some

used full weight-bearing (FWB) stretching, some used non-weight-bearing (NWB) and some used stretching assistance devices such as pulley systems.

Radford *et al* (2006) identified that many of the stretching programmes reviewed were prescribed for home treatment. This may be considered an interesting and important observation as many authors such as Starrett and Cordoza (2013) highlight the importance of individuals being able to perform basic therapeutic exercises at home without the need for regular visits to a therapists, and also identify the importance of client adherence to rehabilitation as a key factor when considering how successful or unsuccessful a programme has been (Wesch, Hall, Prapavessis, Maddison, Bassett, Foley, Brooks & Forwell, 2012). One key conclusion from Radford *et al* (2006) was that there was a positive correlation between the length of time clients spent stretching the triceps surae and the increase of ankle DF ROM. It was suggested at a stretching period of between 15-30 minutes produced an average increase of 3.03^{o} DF. In addition, the trials considered in this systematic review prescribed stretching programmes ranging from 3 days to 6 weeks. However, it could be argued that for many individuals; committing to regular bouts of stretching for such prolonged periods of time may not always be realistic and could lead to decreases in adherence to the stretching programme.

It must, on the other hand, be highlighted that in the case of restricted ankle DF, that soft tissue may not always be the cause of the problem. Therapists should also consider degeneration or general stiffness of articular surfaces around the talocrural, subtalar or inferior tibiofibular joints as possible restrictors. In order to treat joint stiffness, one treatment modality which has received much support is that of Maitland's Mobilisation; or more specifically the use of Maitland's Grade III and IV

mobilisations. These grades of mobilisation are thought to assist in the production of synovial fluid in order to provide joint nutrition and lubrication (Mahendran, Sundaresan, Potturi, & Karthikeyan, 2014).

Green, Refshauge, Crosbie and Adams (2001) conducted a study in to the use of Maitland's passive joint mobilisations with a view to achieving full pain free ankle DF following acute lateral ankle sprains and found that after four treatment sessions 13/19 participants from an experimental group (receiving passive talocrural anterior to posterior mobilisations with RICE (rest, ice, compression and elevation) had been discharged from the study as they had successfully achieved full, pain free, ankle DF. Only 3 participants from the control group, on the other hand, (receiving only RICE) had achieved full, pain free, DF by the fourth treatment session.

Although the study of Green *et al* (2001) offers support to the use of Maitland's passive mobilisations, questions must still be raised as to how Maitland's mobilisations can offer clients an opportunity to continue their treatment away from the therapist's table. Although studies such as that of Cook, Turney, Ramirez, Miles, Haas and Karakostas (2002) found that factors such as years of experience/training were not an accurate predictor of poor inter-rater reliability among physical therapists applying Maitland's mobilisations; all of the participants in such studies have been qualified physical therapists with, at least, undergraduate level training. Therefore it could be suggested that although therapists could demonstrate to clients how they may perform Maitland's mobilisations on themselves, if they do not have the appropriate training and experience there is a chance they may perform the techniques incorrectly and thus fail to achieve their therapeutic goals. This, in turn, suggests that although Maitland's mobilisation techniques do have support in the

literature they still do not offer a treatment which clients can continue to perform as a part of their longer term home management plan.

An alternative mobilisation technique could be that of Mulligan's Mobilisation with Movement (MWM) (Collins, Teys & Vicenzino, 2004). Mulligan's approach combines joint mobilisations with active movements such as a anterioposterior (AP) glide of the talus on the tibia with active dorsiflexion of the ankle in a FWB or NWB position. Claims are made in the literature (Exelby, 1996; Mulligan, 1993, cited by Collins et al, 2004) that through a combination of mobilising the joint while reproducing the functional or problematic movement, significant gains in ROM can be achieved.

Collins *et al* (2004) conducted a study in to the use of MWM in order to improve ankle DF and found that MWM did cause a significant increase in DF ROM over a three day period. It should however, be observed that although the data was statistically significant, results from MWM treatment were compared to a placebo treatment group and a no-treatment group. Another limitation of the study by Collins *et al* is that DF ROM was measured in millimeters (mm), rather than degrees. As a result the conclusions can not be directly compared to the studies reviewed in the aforementioned systematic review by Radford *et al* (2006). This makes it extremely difficult for therapists to hypothesise which treatment may be more effective; static stretching or MWM for increasing DF ROM.

Furthermore the technique of MWM adopted Collins *et al* (2004) still required the presence of a therapist or partner to provide an AP force to the talus, which leaves yet another question mark over whether or not the treatment suitable for clients to use unsupervised. On the other hand Cosby & Grindstaff (2012) recommended a similar MWM treatment technique, however placing emphasis on the 'self-

mobilisation' aspect. Their approach recommended a taut strap be wrapped around the anterior aspect of the talocrural joint and then secured to a stable object behind them, thus creating tension in an AP direction at the client's talocrural joint. The client is then instructed to translate the knee forward to create dorsiflexion at the ankle. The major limitation lies within the lack of supporting evidence as the technique was published in the National Strength and Conditioning Association's Strength and Conditioning Journal as a suggestion rather than an evidence based research article.

One author and clinician; Kelly Starrett, firmly supports the use of a technique referred to as 'Voodoo flossing' or 'tack and floss'. Starrett advocates the use of the technique through his 'Mobility Wod' online mobility and athletic training video series, and in his books 'Ready to Run' (Starrett and Murphy, 2014) and New York Times and Wall Street Journal Bestseller 'Becoming a Supple Leopard' (Starrett and Cordoza, 2013).

Starrett defines the Voodoo floss technique as "…an intermittent, compression-based joint mobilization method that incorporates all the mobility systems simultaneously' (Starrett and Cardoza, 2013 p.217). One of the main claimed benefits of the Voodoo floss technique is that the technique allows individuals to mobilise joints and soft tissues in functional positions. For instance; an individual that may be struggling to achieve full ankle DF during a deep squat may have previously used basic static stretching, Maitland's mobilisations, MWM, or even a combination of these techniques in order to improve their ROM. However, Voodoo flossing enables individuals to 'tack down' (compress) the soft tissues of the tricep surae

group while performing functional movements such as a squat in order to improve their desired position.

Not only does Voodoo flossing allow individuals to mobilise in the exact position they are struggling with, they may also receive the added benefit of increased joint lubrication as the ankle is forced, passively, in to DF, which may stimulate the production of synovial fluid. In addition, Starrett also claims that upon removal of the compression band an influx of blood and nutrients can help to maintain the general health of the soft tissues, particularly the Achilles tendon, as it is known to otherwise have a poor supply of blood (Whiting and Zernicke, 2008).

Starrett and Cardoza claim that the overall aim of Voodoo flossing is to create a global shearing effect in order to restore the sliding surface function of the target tissues. It is claimed that this is achieved by compressing the area of hypothesised restriction, as well at the areas directly above and below the affected area and then mobilising through the full range of movement for between two and three minutes.

However, it seems that the claimed benefits of the Voodoo floss technique are purely anecdotal. Dr. Kelly Starrett's Mobility Wod series has a huge following (over 76,000 followers on Twitter) and a New York Times and Wall Street Journal Bestselling book suggest that may individuals are feeling the benefits of this new technique. As a result there is certainly a need for more research to be conducted in relation to Voodoo flossing in order to examine the use of the technique in a more clinical setting.

It could be suggested that Voodoo flossing employs some very similar principles in terms of movement under compression, however there are studies which exist both in support (Mohr, Long and Goad, 2014) and critique (MacDonald, Penney, Mullaley,

Cuconato, Drake, Behm and Button, 2013) of the use of foam rolling in order to achieve ROM gains. However, foam rolling does not always incorporate the joint mobilisation aspects of treatment available through Voodoo flossing.

When assessing DF ROM there are a number of options including goniometers, inclinometers and tape measures. One of the main issues with assessment of DF ROM is there does not seem to be a clear, standardised method. For instance some researchers have measured with the knee in flexion (e.g. client sitting on the edge of the treatment table), and other measure in standing. Konor, Morton, Eckerson, and Grindstaff (2012) examined the reliability of measuring DF ROM through a weight bearing lunge method. Through the weight bearing lunge, the authors were able to assess DF ROM with a goniometer, inclinometer and tape measure and then compare the reliability of each measure. The study of Konor *et al* suggested that the weight bearing lunge provided a method of assessing DF ROM which can be utilised by a novice tester. Their results showed that assessing with tape measures and inclinometers showed particularly high reliability coefficients (ICC = 0.96 to 0.99). Therefore it can be suggested that the weight bearing lunge could be an excellent method for novice testers to continually assess their own ROM during their home management programme without the need of a therapists or experienced tester.

Konor *et al* suggested that through the weight bearing lunge method; participants should be able to stand with their great toe 10cm from a wall and then lunge forward in order to touch the wall with their knee, without their heel rising from the floor. If participants are unable to do so at a distance of 10cm, it may be reasonable to assume that they are lacking in sufficient DF ROM and may suffer from this, in line with the aforementioned suggestions of Tabrizi *et al* (2000). However, this method

could also allow for a therapist to measure with both a goniometer and tape measure in order to convert ROM to degrees in order to compare with normative data.

Methods

Participants

Prior to any participant recruitment or data collection the research received ethical clearance from the Teesside University ethical committee. To meet inclusion criteria participants had to be free from lower limb injury for 3 months had had to be able to achieve 10cm or less of active DF ROM through the weight bearing lunge. Participants were excluded from the research if there was any possibility that they were pregnant or suffered from any form of circulatory issue. If participants were unsure if they had any condition which would make compression based mobilisations contraindicated they required to consult their GP prior to participation.

10 participants were recruited for the study (M=5, F=5). Participants height (cm), mass (kg) and age (years) were: 171.4cm ± 11.52cm, 72kg ± 8.94kg and 23.8yrs ± 4.66yrs respectively.

Testing

Prior to any testing or intervention procedures all participants were required to complete a general health questionnaire to ensure that they were free of contraindications to treatment. Participants were also provided with an information sheet which summarised the general aims of the research as well as outlined a guide to the testing and intervention procedures. After reading the information sheet participants were given an opportunity to ask the researcher any further questions prior to completing an informed consent form which was kept in a locked cupboard

only accessible by the researcher. Participants were also informed of their right to withdraw from the study at any time if they so wished.

DF ROM was measured in FWB using a standard anatomical tape measure placed on the floor. ROM was measured in FWB, rather than NWB to better simulate ADL such as walking, running or squatting (fig. 1). ROM was measured three times per participant with the average ROM of the three tests being recorded in order to increase internal validity and minimise discrepancies. All participants had DF ROM tested on either their right or left side (selection made at random) and then completed the intervention protocol on that side. All participants were then asked to return 72 hours later to have their opposite ankle assessed and to complete the intervention protocol. 72 hours was selected as a sufficient washout period to try to avoid any residual affects of the intervention protocol affecting the untreated leg.

Immediately following pre-treatment ROM assessment each client completed 150 seconds of Voodoo flossing. Starrett (2013) recommends between 2 and 3 minutes of Voodoo flossing so the decision was made by the researcher to select 150 seconds as a half way point between the upper and lower recommended time frame. The Voodoo floss technique was made up of full ROM exercises such as deep squatting, and raising the foot in to full active DF.

The Voodoo band was applied from the most inferior portion of the Achilles tendon at its calcaneal insertion point starting with approximately 50% tension at the posterior aspect of the lower limb and tension elevated at the anterior, as to not apply a high circumferential compression and focus the compression at the posterior. The band was then overlapped by approximately half of an inch and wrapped in a cephelad direction. Band tension was increased to between 70-75% through the main body of

the Achilles tendon approximately 2cm superior to the calcaneal insertion to towards the muscle belly of the tricep surae (fig. 2). To complete the application of the band, tension was reduced back to around 50%, slightly superior to the muscle belly, and around 5cm of the band had no tension at all, so that it could be left as slack and tucked in to hold in place.

Fig. 1 shows DF ROM test method.

Fig. 2 shows Voodoo floss band application technique.

Once participants had completed their Voodoo floss therapy the band was removed and DF ROM was re-tested on both the right and left side. Participants were then free to leave, but asked not to take part in any form of exercise away from ADL for the next 7 hours. At which point they would return to assess if any changes in DF had occurred since testing immediately after treatment.

Data analysis

Data analysis employed the use of a customised spreadsheet (Hopkins, 2006) in order to make inferences based upon the magnitude of the effect. The use of magnitude based inferences has been supported (Van Shaik & Weston, 2016) in sports science research in order to draw more robust conclusions from the research than those that can be drawn from null-hypothesis testing alone.

Pre-test scores as well as post test scores immediately following treatment (0 hours) and post test scored collected 7 hours following treatment (7 hours) were entered into the spreadsheet. As there were some between subject differences in baseline scores, pre-tests scores were entered as a covariate in order to adjust for the possibility of baseline scores as a confounding variable. The researcher then set the smallest worthwhile effect of the intervention at 0.2SD(±), with moderate effects and large effects set at 0.6± and 1.2± respectively, and confidence intervals were set at 90% as suggested by Batterham & Hopkins (2006).

Results

For the right leg a mean change in ankle DF ROM from pre test (7cm ±1.5cm) to 0 hours (8.15cm ±1.5cm) was calculated as 1.2cm (90% CI 0.5cm-1.8cm) which is considered to be a possibly moderate sized effect but most likely a small effect. Mean chance between right leg at 7 hours (9cm± 1.4) and 0 hours was calculated at 0.9cm (90& CI 0.5cm – 1.2cm) which is considered a possibly moderate or trivial effect but most unlikely harmful.

Left leg mean change scores were calculated between pre test (6.7cm ± 2.07cm) and 0hours (8.65cm± 2.03cm) at 1.9cm (90% CI 1.7cm – 2.1cm) which is considered most likely moderate sized effect. Mean change between 0hours and 7hours was calculated at 0.1cm (90% CI 0.0cm – 0.2cm) which is considered a most likely trivial effect given the pre set smallest and moderate worthwhile effect scores.

Figure 3.

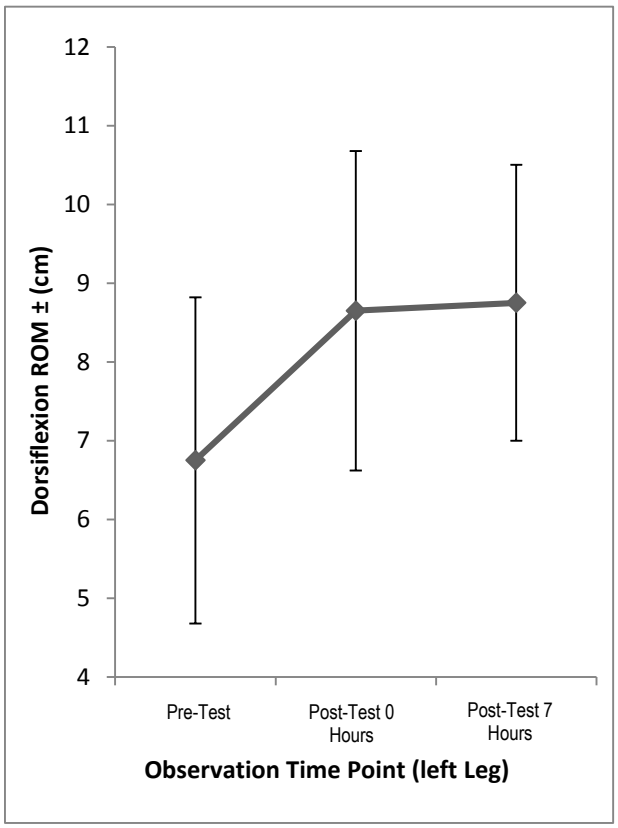

Figure 3 shows left ankle DF ROM ± (cm) observed at pre-test, post test (0 hours) and post-test (7 hours)

Figure 4.

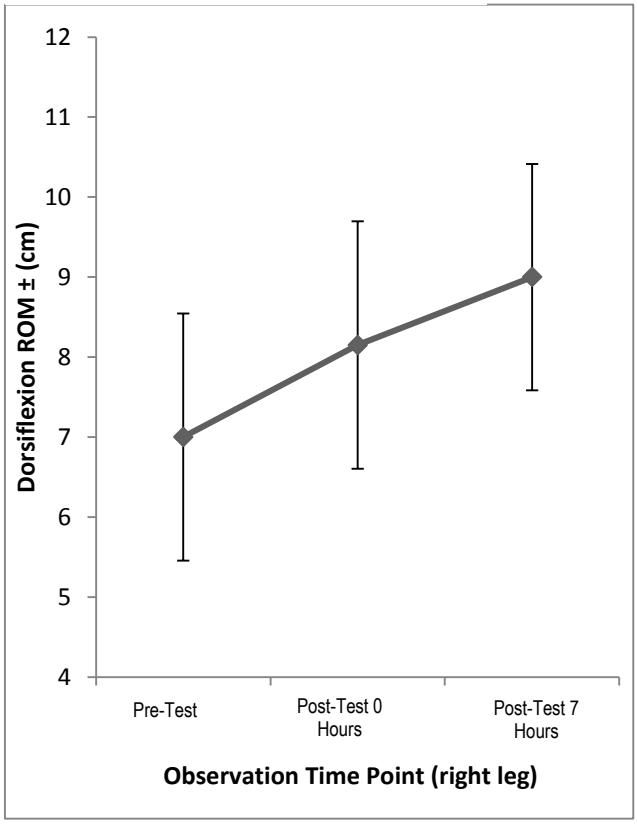

Figure 4 shows right ankle DF ROM ± (cm) observed at pre-test, post test (0 hours) and post-test (7 hours)

Discussion

Restrictions in ankle DF can be the result of a multitude of factors relating to, but not limited to; training history, biomechanics, muscular tightness and joint degeneration. Based on the suggestions of Tabrizi *et al* (2000) that a minimum of between 10º-30º of ankle DF is required in order to perform simple ADL such as walking or descending stairs there is a clear need for interventions to allow individuals to

increase their DF in order to counter ankle ROM deficits. Other suggestions (Fong et al, 2011) have been made that limited ankle DF can also increase ground reaction forces within the knee during landing mechanics of activities such as jumping or running. Increased ground reaction forces are thought to be associated with increased knee valgus; possibility leading to increased risk of injuries to the medial collateral ligament (MCL) and increased risk of non-contact anterior cruciate ligament (ACL) injury, particularly in the female population (Zahradnik, Uchytil, Farana and Jandacka, 2014).

On the other hand it is not only the ankle joint which affects the knee joint, further up the kinetic chain. There are also suggestions (Baumbach, Brumann, Binder, Mutschlier, Regauer, and Polzer, 2014) that knee positioning can also have an affect on movement of the ankle joint. Baumback *et al* (2014) suggested that, in individuals with insufficient ankle DF ROM, that significant increases in active DF can be found when performing active DF with the knee in 20º of flexion compared to the knee in full extension. As a result it was suggested that 20º of knee flexion is sufficient to eliminate tightness of the triceps surae group which may be limiting dorsiflexion. One problem here is that may sporting movements which require ankle DF cannot be performed with the knee in such a position.

As some researchers advocate the use of stretching programmes (Radford et al, 2006) or the use of joint mobilisation techniques such as those of Maitland (Green et al, 2001) or Mulligan (Collins et al, 2004); alternative techniques such as 'Voodoo flossing' seem to be gaining popularity. However, limited research has been conducted into their use.

The current study looked at the immediate affect of the use of Voodoo floss treatment on ankle dorsiflexion range of motion and the residual affect 7 hours post-treatment in order to establish whether or not there is evidence to support its use. From a sample size of 10 participants (M=5, F=5) of varying ages, but all unable to achieve the recommended amount of ankle DF in order to complete the standard knee to wall DF assessment of 10cm, it was found that Voodoo flossing lead to a possibly moderate sized beneficial effect, and most likely small beneficial effect in the right leg and a most likely moderate sized beneficial effect in the left leg.

As the sample size was relatively small there was a high chance of the researcher committing a type II error, therefore statistical analyses were conducted using magnitude based inferences in order to provide a better picture of the magnitude of the difference between the means and standard deviations of the pre treatment DF scores, DF scores at 0 hours post-treatment, and DF scores at 7 hours post-treatment. It was important for the researcher to calculate magnitudes of the effects as, one of the issues in the available research related to increasing ankle DF is that many articles used degrees of movement as an outcome measure, whereas others used centimeters. As a result it can be difficult to compare the results of different articles when dealing with different units of measurement. Furthermore statistical significance only provides researchers with a limited amount of information in that they can tell if one set of means is significantly different to another set of means, it is more difficult to establish the magnitude of effects. By employing this method researchers can then set a threshold of smallest worthwhile effect, which can arguably increase the external validity of research outcomes.

What is clear from the results of the current research is that Voodoo flossing can lead to worthwhile increases in available DF ROM immediately following treatment, but furthermore these increases in ROM can still be observed 7 hours after completing 150 seconds of treatment. However, the results of the current research still leave some unanswered questions. Interestingly the right leg DF scores continued to increase from 0 hours post-treatment to 7 hours post-treatment whereas the left leg mean scores did increase slightly from 0 hours post-treatment to 7 hours post-treatment; these increases were deemed to be insignificant. From the available data in this research it cannot be identified why the right leg measurements for the group continued to increase over a longer period of time.

Another interesting observation from the current results is that although the left did not seem to continue to improve from 0 hours to 7 hours post-treatment, the left side did seem to respond much better to treatment than the right side. This can be observed by looking at the mean change scores at 0 hours post-treatment for both groups. The right side responded with a change score of 1.2cm (90% CI 0.5cm – 1.8cm), where as the left side responded with a change score of 1.9cm (90% CI 1.8cm – 2.2cm).

Herein lies a further possible flaw in the current research. Although participants completed a basic questionnaire prior to participation; this was only to assess their suitability for the research. The researcher missed an opportunity to gain more information on the participants which could have helped to provide explanations as to why the two legs seemed to respond differently. Future studies could look to conduct further biomechanical analysis on participants prior to taking part in the study. Further background information such as training history or an analysis of

movements such as jumping and landing could help researchers to assess aspects of the participant such as tendon stiffness. Individuals with greater levels of tendon stiffness such as sprinters or plyometric based athletes may respond differently to the compression and tendon lengthening aspect of the treatment as greater tendon stiffness may provide greater resistance to the treatment, particularly given the extremely robust nature of the Achilles Tendon (Peltonon, Cronin, Stenroth, Finni and Avela, 2012).

Conclusion

The current research supports existing research such as that of Radford *et al* (2006) and Collins *et al* (2004) in concluding that ankle dorsiflexion range of motion can be increased though home management programmes for clients. However, the research goes on to support adding a compressive element to self-mobilisation and stretching of the soft tissues of the tricep surae group through the use of Voodoo flossing. Therefore the current research supports to claims of Starrett & Cardoza (2013) that Voodoo flossing is an effective technique for ROM increases around the ankle joint and furthermore that Voodoo flossing can be an effective intervention which clients can implement on their own, without the need for continuous support from the therapist.

However, there may be a need for stricter guidelines on the application of Voodoo flossing as currently there are only brief guidelines of between 2 and 3 minutes of full ROM movements. There are no recommendations made of how many sets of movements. Other limitations of the application of Voodoo flossing are related to the resistance, or 'stretch', applied through the band. There are suggestions of between 50%-75% of tension however this may be considered subjective for each person

applying the band. It should also be said that there is not yet any guidelines for the use of Voodoo flossing for populations with circulatory issues or issues such as rheumatoid arthritis, however at this point the current author would consider these conditions to be contraindicated for Voodoo flossing or clients should at least consult their doctor.

What cannot be concluded from the current research, however, is whether or not the treatment is suitable for the entire population. Due to the small sample size and the failure of the sample to provide an accurate representation of the population; further research is required using a wider sample. Additional benefits could also come in the form of a more detailed biomechanical analysis of participants as well as further investigation in to where improvements in ROM come from as a result of Voodoo flossing. For instance; it is not yet clear whether it is the muscular tissue, fascia, tendinous tissue or the joint itself which response best to the treatment, or even a combination of all of these elements. Further investigations in to tissue detailed tissue adaptations to Voodoo flossing were outside of the ethical boundaries of the current research.

Furthermore the current research does not provide information on the longer lasting affects of treatment >7 hours, or the longer term adaptations to continued use of Voodoo flossing. As a result of the current research there seems to be a need for more detailed research in the area which can make direct comparisons between Voodoo flossing and more conservative interventions over a prolonged period of time in order to provide therapists and clients with more conclusive supporting evidence.

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