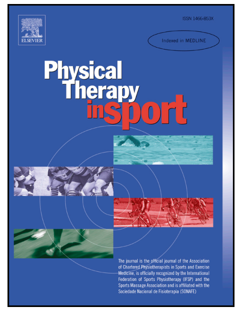

The effects of tissue flossing on ankle range of motion and jump performance

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The effects of tissue flossing on ankle range of motion and jump performance

Original Investigation

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Running Head: *Floss bands and ankle ROM*

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Abstract

Objectives: Tissue compression and partial vascular occlusion using band flossing results in re-perfusion of blood to the muscle tissue that may ultimately increase range of motion (ROM) and reduce risk of injury. However, the effect of band flossing on ankle ROM and jump performance is yet to be evaluated.

Design: In a crossover design, participants performed a number of tests pre and post the application of a floss band to one ankle (FLOSS), with the contralateral ankle acting as the control (CON).

Setting: University laboratory.

Participants: 52 recreational athletes (29 male/ 23 female).

Main outcome measures: Pre and post measures included a weight-bearing lunge test (WLBT), ankle dorsiflexion (DF) and plantarflexion (PF) ROM, and single leg vertical jump height and velocity.

Results: FLOSS resulted in significant enhancements in all test measures pre to post ($p<0.01$), with no significant changes pre to post for CON ($p>0.05$). All pre to post changes were associated with *small* effect sizes for FLOSS compared to CON.

Conclusion: Floss bands applied to the ankle increase dorsiflexion and plantarflexion ROM and improve single-leg jump performance in recreational athletes. The results from this study suggest that floss bands may be used for injury prevention and athletic performance.

Keywords: *flossbands, mobility bands, vascular occlusion, ischemic pre-conditioning, ROM*

Introduction

The anecdotal use of floss/mobility bands, or “tissue flossing”, amongst athletes is becoming a popular strategy to increase joint range of motion (ROM), enhance prevention or rehabilitation from injury and improve athletic performance, despite limited evidence for its efficacy. Tissue flossing involves the wrapping of a thick rubber band around a joint or muscle, partially occluding blood-flow while often concomitantly performing ROM tasks for 1-3 minutes. This technique gained popularity through the book by Starrett and Cordoza (2013), where the authors introduced floss band compression for increasing ROM and postulated that the potential mechanisms behind the benefit of using floss bands may be attributed to fascial shearing and/or reperfusion of blood to the muscle.

While the research studies regarding tissue flossing are currently lacking, the mechanisms involved may be similar to that of ischemic preconditioning/blood-flow occlusion/restriction training, whereby reperfusion of blood to the occluded area, enhanced growth hormone and catecholamine responses are suggested to improve exercise performance (Reeves et al., 2006; Takarada et al., 2000). Furthermore, in animal models, ischemic preconditioning has been shown to improve muscle contraction efficiency, possibly by enhancing muscle force and contractility (Lawson & Downey, 1993) and/or via increased efficiency of excitation-contraction coupling (Pang et al., 1995).

To the authors knowledge, the extent of research examining the effect of tissue flossing in an athletic setting is limited to two studies, published as conference proceedings (Bohlen et al., 2014; Plocker, Wahlquist, & Dittrich, 2015). Bohlen et al., (2014) examined the effects of 14 days of band flossing combined with joint mobilization and resistive exercise on calf blood flow and plantar/dorsiflexion strength in five participants. Participants performed unloaded squats, heel raises, active dorsiflexion and passive ankle mobilization with floss bands applied to one knee while the contralateral leg acted as the control. Dorsiflexion peak torque increased 22% in the treatment leg (p=0.06), while there was no change in the control leg. The authors also reported no change in blood-flow parameters between legs following the 14-day study.

In contrast, Plocker et al., (2015) studied the effect of applying floss bands to both shoulders in 17 male athletes in an acute setting. Subjects attended an experimental session whereby the researchers wrapped both shoulders with a floss band, and led subjects through shoulder ROM exercises. Upon band removal, ROM measurements (internal and external rotation) were taken using a goniometer. A 3D accelerometer was then used to measure upper extremity power during the bench press. The control session involved the same shoulder exercises without the use of the floss band modality. The study reported that despite trends towards improvements, there were no significant increases in ROM or upper-body power ($p>0.05$) following the floss band treatment when compared to the control. Researchers concluded that it was difficult to cover the entire shoulder (rotator cuff complex) with the wrapping technique, potentially limiting the effectiveness of improving shoulder ROM. Other joints, such as the ankle, may be easier to cover using the floss band wrapping technique.

Ankle dorsiflexion ROM is an important component in the absorption of lower limb load when landing from a jump, as common in most sports (Malliaras, Cook, & Kent, 2006). When landing from a jump, the forefoot usually contacts the ground and then the ankle moves into dorsiflexion. Indeed, it has been suggested that reduced ankle dorsiflexion range may be a risk factor for the development of patellar tendinopathy and is also a risk factor for anterior cruciate ligament (ACL) injury and other lower-limb injuries in athletes (Fong, Blackburn, Norcross, McGrath, & Padua, 2011; Gabbe, Finch, Wajswelner, & Bennell, 2004; Malliaras et al., 2006). Moreover, restricted dorsiflexion has been implicated as a contributing factor in overuse injuries of the lower limb and foot (Warren & Jones, 1987).

Given the relatively novel technique of tissue flossing has only been examined in two studies, with contrasting results, the modality requires further research. Furthermore, it is well known that improvements in ankle ROM may lead to enhanced performance in many sport, exercise and rehabilitation settings (Conradsson, Fridén, Nilsson-Wikmar, &

Ang, 2010; Larson, 2014; Malliaras et al., 2006; Tabrizi, McIntyre, Quesnel, & Howard, 2000), making it an obvious area for investigation. Therefore, the aim of the current study was to evaluate the use of floss bands applied to the ankle joint, on subsequent ankle ROM and jump height in recreational athletes.

Methods

Participants

Fifty-two recreational athletes (29 male/ 23 female, mean ± SD; age: 20 ± 4 years) volunteered to participate in the current study. Participants were recruited through a University sport science under-graduate program. To be eligible for the study, all participants were required to be participating in regular physical exercise sessions (>3 times per week) and free from lower-limb injuries (hip, knee or ankle) that may have affected their ability to perform the single-leg jumps. Written informed consent was obtained from each participant, and ethical approval was obtained from the Human Research Ethics Committee of the institution.

Experimental Design

Participants performed a number of lower-leg tests pre and post application of a floss band (FLOSS) or no floss band (CON) to the ankle-region. For each participant, the ankle that had no floss band served as the control for pre and post testing, while the ankle with the floss band served as the experimental treatment. Participants attended a sport science laboratory for a single testing session. Following the pre tests, in a randomised (computerised random number generator), counterbalanced design, researchers applied a floss band (Life Flossbands, Sydney, Australia), to either the right (n = 26) or left (n = 26) ankle of participants. Post tests were then performed in the same order as the pre tests. The order of tests for all participants were as follows: the weight bearing lunge test, plantarflexion ROM, dorsiflexion ROM and single leg vertical jump test.

Figure 1 – The floss band ankle bandaging technique used by researchers

Methodology

Weight-bearing lunge test (WBLT)

The WBLT was performed pre and post flossing as a measure of dorsiflexion range of motion. Participants placed their foot along a measuring tape on the floor, with their big toe against the wall and both their toe and heel on the centerline of the measuring tape.

Participants were then asked to progressively move their toe further back from the wall on the measuring tape, repeating the lunge movement until the maximum distance at which they could tolerably lunge their knee to the wall without heel lift was found. Measurement was made using the tape measure from the tip of their big toe to the wall. The weight-bearing lunge test (WBLT) is a functional and reliable method to indirectly assess dorsiflexion by measuring the maximal advancement of the tibia over the rearfoot in a weight-bearing position (Bennell et al., 1998). Previous investigators have reported robust inter-tester and intra-tester reliability associated with the assessment of WBLT performance in healthy adults, with high levels of test-retest reliability demonstrated (standard error of measurement = 1.1°, 95% CI = 2.2) (Bennell et al., 1998).

Dorsiflexion and Plantarflexion ROM

Both dorsiflexion (DF) and plantarflexion (PF) range of motion tests were performed using a handheld manual goniometer (RBMS®, USA) pre and post flossing. Tests were performed while participants were in a supine position. The center of the goniometer was placed just below the lateral malleolus of the ankle, with one arm lined up through the lateral aspect of the fibula and the other arm lined up with the 5th metatarsophalangeal joint. Participants were instructed to perform a maximal dorsiflexion movement and a maximal plantarflexion movement and measurements (degrees) were taken for analysis. Acceptable intra-tester reliability for assessing ankle ROM using a manual goniometer has been reported previously (ICC = ~0.85) (Youdas, Bogard, & Suman, 1993).

Single-leg vertical jump test (JUMP)

Data regarding the maximal jump height ($JUMP^H$) and the peak jump velocity ($JUMP^V$) were measured using a linear position transducer (Gymaware, Kinetic Athlete, Canberra, Australia) pre and post flossing. The Gymaware device was calibrated before each jump, according to manufacturer's instructions. $JUMP^H$ was measured in metres, while $JUMP^V$ was measured in $m.s^{-1}$. Single-leg countermovement jumps were performed and the best of three attempts for each leg was recorded and used for subsequent analysis. High levels of validity (typical error of estimate of 0.00m for jump height and 0.01m/s for peak and mean velocity) for the Gymaware device have been reported elsewhere (Hori & Andrews, 2009).

Kikuhime pressure measurement

In a selection of participants (n = 12), interface pressure between the skin and the floss band was measured to assess the level of compression (mmHg) achieved by the wrapping technique. The Kikuhime pressure monitor (MediGroup, Melbourne, Australia) sensor was placed on the anterior aspect of the tibia on the midline between the lateral and medial malleolus (Figure 2). The Kikuhime pressure monitor has been shown to be a valid (ICC = 0.99, CV = 1.1%) and reliable (CV = 4.9%) tool for use in the sport setting (Brophy-Williams, Driller, Halson, Fell, & Shing, 2014).

Figure 2 – The Kikuhime pressure monitoring device applied under the floss band.

Application of floss band

A standard ankle-bandaging technique was used by researchers by applying the floss band accordingly: Across the transverse of the foot, aligned with the distal head of the metatarsals of the foot. The wrap circulated around the foot twice, followed by 3 wraps completed in a figure 8 (to lateral malleolus, around the achilles, to medial malleolus, towards the distal head of the 5th metatarsal, around the bottom of the foot and back to the beginning). Each subsequent wrap overlapped the previous by ~50%, before securing the remainder of the band underneath the final wrap (Figure 1). Once the floss band was applied, in a seated position, participants performed an active ROM task - 20 repetitions of plantarflexion and dorsiflexion, simultaneously on both the CON and FLOSS ankles. Participants were instructed to perform both plantarflexion and dorsiflexion to their extreme ranges of motion and completed the mobility exercises within two minutes. After two minutes, the floss band was then removed and the participants were instructed to stand up and walk around for one minute to allow for blood flow to return to the foot.

Statistical Analysis

Statistical analyses were performed using the Statistical Package for Social Science (V. 22.0, SPSS Inc., Chicago, IL). A two-way repeated measures ANOVA was performed to determine the effect of different treatments (FLOSS or CON) over time (pre/post) on all measured variables, with a Bonferroni adjustment if significant main effects were present. Analysis of the studentized residuals was verified visually with histograms and also by the Shapiro-Wilk test of normality. A Student's paired t-test was used to determine pre to post differences for each condition and also between treatments for pre test values. Descriptive statistics are shown as means ± standard deviations unless stated otherwise. Standardized changes in the mean of each measure were used to assess magnitudes of effects and were calculated using Cohen's *d* and interpreted using thresholds of 0.2, 0.5, 0.8 for *small*, *moderate and large*, respectively (Cohen, 1988). An effect size of ±0.2 was considered the smallest worthwhile effect with an effect size of <0.2 considered to be *trivial*. The effect was deemed *unclear* if its 90% confidence interval overlapped the thresholds for *small* positive and negative effects (Batterham & Hopkins, 2006). Statistical significance was set at $p<0.05$ for all analyses.

Results

Mean pressure (± SD) applied by the floss band in a cohort of the study population (n=12), as identified using the Kikuhime pressure monitor, was 182 ± 38 mmHg. There were no significant differences between FLOSS and CON for any of the measured variables pre test ($p>0.05$). There was a statistically significant interaction between treatment (FLOSS/CON) and time (pre/post) for the WBLT, DF and JUMPv measures ($p<0.01$), but not for PF or $JUMP_H$ ($p>0.05$, Table 1). FLOSS resulted in significant enhancements in all test measures pre to post application of the floss bands (WBLT, PF, DF $JUMP_H$, JUMPv, $p<0.01$), while there were no significant differences pre to post CON ($p>0.05$). All measures were all associated with *small* effects sizes in favour of FLOSS when compared to CON (Table 1).

The WBLT resulted in a 1.8 cm increase pre to post for FLOSS, compared to a 0.2 cm increase in CON. ROM for both PF (+5 degrees) and DF (-7 degrees) were improved in FLOSS, compared to just +2 degrees for PF and -1 degree for DF in CON. Similar increases were observed pre to post for $JUMP_H$ in both FLOSS and CON (0.04 m and 0.02 m, respectively). $JUMP_V$ was further enhanced (pre to post) in FLOSS (0.15 $m.s^{-1}$) when compared to CON (0.03 $m.s^{-1}$).

Table 1 – Pre and post measures (mean ± SD) for floss band (FLOSS) and control (CON) trials and effect sizes for the comparison of change between groups (±90% confidence intervals). # Represents significant difference between pre and post (p<0.01), * Represents significant intervention * time interaction between groups (p<0.01).

	FLOSS (mean ± SD)		CON (mean ± SD)		FLOSS - CON Effect size (±90%CI)
	Pre	Post	Pre	Post	
WBLT (cm)	10.9 ± 6.0	12.7 ± 6.5#	11.4 ± 6.7	11.6 ± 6.5	0.29 ±0.09* *small*
PF (degrees)	162 ± 16	167 ± 14#	162 ± 13	164 ± 14	0.22 ±0.19 *small*
DF (degrees)	95 ± 12	88 ± 13#	93 ± 12	92 ± 12	-0.49 ±0.21* *small*
$JUMP^H$ (m)	0.23 ± 0.07	0.27 ± 0.08#	0.24 ± 0.07	0.26 ± 0.15	0.28 ±0.32 *small*
$JUMP^V$ ($m.s^{-1}$)	1.88 ± 0.35	2.03 ± 0.37#	1.94 ± 0.53	1.97 ± 0.44	0.22 ±0.14* *small*

Discussion

The current study is the first to investigate the use of floss bands applied to the ankle on dorsiflexion and plantarflexion ROM and subsequent vertical jump performance. The findings from our study show significant improvements in all ROM measures as well as single-leg jump performance following the application of a floss band while performing ~2 minutes of active ROM exercises, in a group of 52 recreational athletes ($p<0.01$, Table 1). All results were associated with a *small* effect size in favour of the floss band treatment. The *small* but significant effects found for tissue flossing may provide practical implications for numerous settings including the use of the technique to enhance injury prevention, injury rehabilitation and athletic performance.

While this is the first study to evaluate the effect of floss bands on the ankle joint, our findings are in contrast to the only other previous study evaluating the effect of floss bands on ROM and performance in an acute setting (Plocker et al., 2015). Plocker et al. (2015) did not find any significant improvements in shoulder ROM or upper-body power following the application of floss bands. The only other study, to our knowledge, to evaluate the use of floss bands in an athletic setting, assessed the use of this technique in a chronic (14-day) setting while applying the band to the knee during daily exercises. Similar to the findings in the current study, the authors reported benefits to dorsiflexion measures following the experimental period. The potential improvements to ankle ROM following band flossing may apply to areas other than athletic performance, including their potential as an injury prevention method.

Although the majority of studies investigating ACL injury and landing biomechanics have focused on the knee and hip joints, considerably less attention has been devoted to the ankle. Ankle plantarflexors and dorsiflexors play a substantial role in the absorption of landing forces (Malliaras et al., 2006). Indeed, Fong et al. (2011) has shown that greater passive ankle dorsiflexion ROM was associated with greater knee-flexion displacement and smaller ground reaction forces during landing in 35 active participants. These biomechanical results are considered to lower the risk factors for ACL injury (Griffin et al., 2006; Hewett et al., 2005), therefore Fong et al. (2011) indicated that any techniques that increase plantarflexor extensibility and dorsiflexion ROM may attenuate ACL injury risk by placing the lower extremity in a position consistent with reduced ACL loading. Given we were able to significantly improve both plantarflexion and dorsiflexion ROM through the use of floss bands in the current study, possibly through the fascial shearing mechanism (Starrett & Cordoza, 2013), this may prove to be an appropriate technique to use in addition to a warm-up before sporting events where jumping is required, in order to decrease the risk of lower-limb injury. Furthermore, results from the current study would suggest that jump performance can be enhanced following the application of floss bands to the ankle joint.

The physiological mechanisms by which performance may be improved following band flossing are difficult to determine, and since these were not measured in the current study, any theories are somewhat speculative. However, the partial vascular occlusion effect that band flossing has on the joints may cause a number of physiological responses following the removal of the band. These responses may include reperfusion of blood to the area and altered hormonal responses (Takano et al., 2005). More specifically, research has shown that following occlusion (~200mmHg) to the upper leg using a tourniquet during resistance exercise, growth hormone and norepinephrine levels significantly increase ~15 minutes after the occlusion is released (Reeves et al., 2006; Takarada et al., 2000). Furthermore, Morales et al, (2014) has suggested that elevated acute norepinephrine are associated with improved vertical jump ability. It is therefore plausible that these same hormonal responses were achieved in the current study with floss bands applied (~182mmHg), potentially contributing to enhanced jump performance ~5 minutes following the removal of the floss bands. Lawson & Downey (1993) suggested that ischemic preconditioning in rat skeletal muscles led to improved force and contractility as well as decreased fatigue. However, the mechanisms behind repeated muscle-contractions are likely to be different to those of one-off jump performance and mechanistic human research is still lacking.

We would recommend that these physiological mechanisms, including the localised blood-flow and hormonal responses following band flossing, are measured in future research studies on this technique. Further research is also warranted investigating the timeline of both performance and ROM improvements with band flossing. For example, the current study showed improvements in jump performance and ROM ~5 minutes following the application of a floss band. Whether or not these benefits are still observed 5+ minutes following the use of this technique are yet to be determined. A limitation of the current study was that only one ankle was assessed with the floss band. It would be appropriate to apply the floss bands to both ankles and evaluate jumping and other lower-body performance parameters (e.g sprinting, leg strength and power). A further limitation in the current study was the lack of a placebo/sham condition. Indeed, the psychological advantage that may be associated with the intervention can not be discounted. Future research may consider a parallel-group design that incorporates a placebo group.

Conclusion

The current study is the first study to describe the use of band flossing to improve ankle ROM and jump performance in recreational athletes. The potential benefits regarding the results of this study may have a significant impact in the sport setting. More specifically, our results would suggest that including band flossing on the ankle joint before taking part in any sports that require jumping actions, may not only improve performance, but may also provide a novel strategy for injury prevention, through increasing ankle ROM.

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- Floss bands applied to the ankle for ~2mins increase dorsiflexion and plantarflexion ROM
- Application of a floss band to the ankle may improve subsequent single-leg jump performance
- Floss band use during a warm-up may reduce risk of injury and improve performance in athletes

All ethical guidelines outlined by the journal have been followed. Ethical approval was also granted for this study by the University of Waikato. The work has been carried out in accordance with the Declaration of Helsinki