P-ISSN 2586-9000
E-ISSN 2586-9027
Homepage : https://tci-thaijo.org/index.php/SciTechAsia
Science & Technology Asia
Vol.26 No.2 April - June 2021
Page: [145-154]

Original research article

The Application of Tissue Flossing During Plyometric Exercise for the Prevention of Delayed Onset Muscle Soreness

Thanawat Kitsuksan*, Surachart Nartprayut, Punnita Sawangmanee, Waruenaporn Klainin, Teerapat Laddawong, Chuanpis Boonkerd

Department of Physical Therapy, Faculty of Allied Health Sciences, Thammasat University, Pathum Thani 12120, Thailand

Received 5 October 2019; Received in revised form 2 May 2020
Accepted 16 July 2020; Available online 25 June 2021

ABSTRACT

Previous studies have revealed that compression therapy has a significant effect on relieving soreness following exercise-induced delayed onset muscle soreness. However, there is a lack of information about this intervention during strenuous exercise. Therefore, the purpose of this study is to examine the application of tissue flossing (compression technique) during plyometric exercise for the prevention of knee extensor delayed onset muscle soreness. Eighteen low-active healthy young male adults (aged 18-25 years) were randomly assigned to equally sized groups for either tissue flossing (TF) (n=9) or non-tissue flossing intervention (CON) (n=9) during plyometric exercise. Participants engaged in 100 drop-jumps to induce muscle soreness. Pain scale reports and peak torque of knee extensor were collected before exercise and then after exercise at 1, 24, 48, 72, and 96 hours during the recovery phase. Analyzing the data by performing the Friedman test and Wilcoxon's signed rank test revealed no statistically significant difference between the two groups with respect to indirect indices of muscle soreness throughout the study ($P > 0.05$). In conclusion, the application of tissue flossing during plyometric exercise for the prevention of delayed onset muscle soreness is either better or no worse than without flossing. Clinical trial reg. no. TCTR2019091105, clinicaltrials.in.th

Keywords: Application; Compression; DOMS; Plyometric; Prevention

1. Introduction

An individual's soreness severity is influenced by several factors. A previous study found that individuals with a lower physical activity level when exercising vigorously, will have their muscles fatigue easier than those with a moderate or high physical activity level [1]. Delayed-onset

***Corresponding author:** thanawat.k@allied.tu.ac.th **doi:** 10.14456/scitechasia.2021.34

muscle soreness (DOMS) is considered a common sports injury due to overexertion [2]. The signs and symptoms of DOMS may include dull pain, tenderness, stiffness, swelling, and decreased strength of the exercised muscles, usually resulting from the destruction of ultrastructural components of the muscle fibers, cell membranes, and sarcomeres. This eventually leads to an inflammatory response and results in the perception of pain and soreness, hence, DOMS is a symptom of exercise-related muscle pain developing after intense and unaccustomed exercise; this pain will usually peak at around 24 to 72 hours and eventually disappears 5-7 days post exercise [3]. Therefore, exercised muscles should receive proper treatment in order to prevent further injuries resulting from overtraining, and to reduce stress in other tissues that compensate for the initial soreness [4]. There are various methods for relieving the signs and symptoms of muscle soreness such as low intensity exercise, cryotherapy, heat therapy, electrotherapy, massage therapy, myofascial release, and stretching which have shown insufficient evidence for their effectiveness [5, 19]. However, these methods are commonly provided by physical therapists to individuals suffering from DOMS.

Compression therapy has long been shown to be an effective intervention in relieving DOMS [6-8, 19]. Previous studies have revealed that the compression force provided from compression garments helped to reduce muscle fatigue, modulated the decline in muscle strength, and accelerated recovery by supporting and realigning muscle fibers to be closer to their normal condition during exercise sessions, or even in the recovery period [9-10]. Tissue flossing is one type of compression technique used to treat DOMS; it involves wrapping a thick rubber band around the muscle or joint and then performing some active movements (AROM) for a short period of 1-3 minutes during compression [11]. Previously, this method was introduced to improve the immediate (short-term) performance on range of motion in those with musculoskeletal disorders. Nowadays, tissue flossing is becoming a popular practice amongst athletes used to improve sports injury prevention, performance, and rehabilitation [11].

In the literature, to the best of the knowledge of the authors, research on the effects of tissue flossing on DOMS using a flossing-band (elastic band) is limited to only two studies. Megan et al. (2014) [12] found that tissue flossing by band, applied after high intensity eccentric resistance exercise, resulted in a significant increase in knee extensor peak torque during the recovery period. The other of the two studies, Prill et al. (2019) [13], found a significantly lower level of perceived soreness of those in the flossing group, compared to those in the non-flossing group post exercise, and suggested that tissue flossing appears to be an effective approach to treating DOMS. The evidence suggests that the application of compression therapy (tissue flossing) applied after exercise has a significant effect on DOMS; in addition, compression therapy is commonly practiced by many physical therapists during the acute phase of rehabilitation, when an individual has injured a muscle, ligament, or tendon.

However, there is insufficient evidence-based management strategies for tissue flossing during plyometric exercise to treat DOMS and there is no published data to support the application of tissue flossing as a prevention strategy. Due to it being simple, low-cost, and convenient to be applied during exercise, tissue flossing may not be worse than no effect or even better than other compression techniques. These practical benefits might be some possible reasons for using flossing for preventing and attenuating muscle soreness after exercise. We hypothesized that performing tissue flossing in tandem with a drop-jumping exercise will protect knee extensor muscles from DOMS more than performing drop-jumps without tissue flossing. To test this hypothesis, we compared these 2 interventions using an exercise-induced muscle damage (EIMD) protocol.

The aim of this study is to examine the application of tissue flossing during plyometric exercise and its effectiveness in preventing DOMS in the knee extensors of study participants.

2. Materials and Methods

2.1 Participants

Eighteen low-active healthy young male adults (aged 18-25 years) volunteered to participate in this study. All participants were randomly selected from the population of Thammasat University students (Rangsit campus). The inclusion criteria were as follows: 1) a body mass index between 18.5 - 22.9 kg/m^2, 2) a total score of physical activity MET minutes per week of < 600 as quantified by the Global Physical Activity Questionnaire (GPAQ), 3) participants must answer 'no' to all questions in the Physical Activity Readiness Questionnaire (PAR-Q) and 4) no experience with lower-limb strength training for the past 6 months. The exclusion criteria were as follows: 1) participants have a cardiovascular disease, 2) participants have a musculoskeletal pathology that may impair their ability to perform the plyometric drop-jump exercise, 3) participants have a dermal pathology of a lower-limb and 4) participants have a rubber or latex allergy. To reduce the influence of confounding variables, any participant who experienced relief from the signs and symptoms of muscle soreness during the recovery period was removed from the data analysis according to the withdrawal criteria.

2.2 Experimental design

This study was designed as a randomized, controlled, and double-blind study. The experimental protocol was approved by the human research ethics committee of Thammasat University No. 3 (COA No. 066/2561). Informed consent was collected from participants. Eligible participants who met the inclusion criteria were randomly assigned by simple random sampling (SRS) using a lottery method, forming two equally sized groups: a tissue flossing (TF, n=9) group, and a non-tissue flossing group (CON, n=9), as shown in Fig. 1. Investigators responsible for recording study outcomes were blind to participant group allocation. All participants were instructed to complete all the testing parameters for 5 days. First day visiting, pre-assessments were conducted as follows: 1) characteristics of participants (age, weight, height, BMI, and physical activity level), 2) pain scale, and 3) peak torque of knee extensor. After completing the pre-assessment, participants performed the plyometric exercise (drop-jumps) to induce muscle soreness. Reassessments were conducted at 1-hour post-exercise. For days 2-5, each participant had to return at the same time 4 days in a row to repeat the reassessment procedures every 24, 48, 72, and 96 hours.

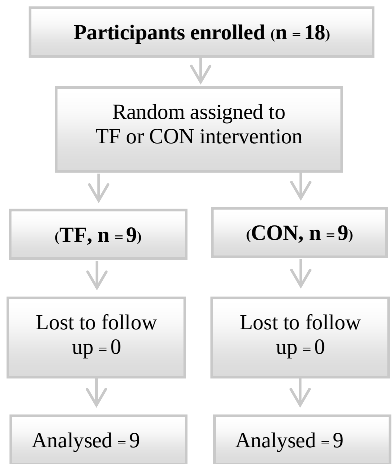

Fig. 1. Consort flow diagram of enrolled participants in a randomized controlled trial.

2.3 Pain scale

Perceived sensation of DOMS was measured by self-assessment on a visual analogue scale of 100 millimeters during performance of an unweighted squat [14]. It has been shown that a visual analogue scale is a valid and reliable tool for measuring pain [15]. Due to self-reported outcomes and the blinding of the participants, the same investigator must also be blinded [13]. All participants were instructed to bend their knees close to 90 degrees from an upright standing position and hold for at least 5 seconds. The participants then marked their level of pain on a visual analogue scale. All participants produced six values for their perceived DOMS throughout the study. All data were recorded and prepared for analysis.

2.4 Peak torque of knee extensor

Muscle strength was assessed using an isokinetic dynamometer Biodex system 3 (Biodex Inc., Shirley, NY, USA). The same experienced investigator conducted all testing parameters and was blind to the participant group allocation. Before and after isokinetic testing, all participants were instructed to engage in self-active stretching of their quadriceps femoris, hamstring, and gastrocnemius muscles to warm-up and prevent further injuries. Isokinetic angular velocity was set at 60°/ s for all measurements. Range of motion was set between 0° and 80° with a total range of motion of 80 degrees from knee flexion to knee extension [14, 16]. Testing was conducted for both quadriceps and hamstring groups simultaneously only in the dominant leg. Appropriate calibration and gravity correction were performed prior to each testing session [16]. The total testing sets of isokinetic data were a-6 repetitions with submaximal effort and a-4 repetitions with maximal effort with a one-minute rest between sets. Verbal, visual, and auditory information were given to each participant during testing. The coefficient of variation (CV) of the four maximal trials must have been lower than 15%. All participants produced six values of isokinetic data throughout the study. All data were then recorded and processed for analysis.

2.5 Application of tissue flossing

Only the participants in the tissue flossing group received the application of tissue flossing during plyometric exercise, coming from the same experienced physical therapist. A blinding of the physical therapist was not practical, because the therapist needed to know on which limb he had to apply tissue flossing. The dominant thigh of each participant was measured from the greater trochanter to the lateral epicondyle of the femur, with a standard measuring tape, and was then divided into 3 parts (upper, middle, and lower thigh) [17]. The compression was implemented using a Flossband (Sanctband Active & Sanctuary Health Sdn. Bhd, Perak, Malaysia) with a length of 2.1-meters, a width of 5-centimeters, and a thickness of 1.3-millimeters. The intervention used in this study was a modified version of one from a previous study, done by wrapping the band around the middle thigh from distal to proximal with a stretch of about 50% of the band’ s maximum stretch. The band was then stretched and exerted compressive force (Interface pressure) on the quadriceps femoris. The therapist reduced the stretch to about 25% of band’s maximum stretching while wrapping around the hamstring. The flossing band was wrapped around the middle thigh in a circular fashion during upright standing by overlapping less than half of the underneath band width. This applied method aimed only to support the whole quadriceps femoris muscle as much as possible during exercise and does not typically cause any blood-flow occlusion/restriction, similar to what was found in general knee support compression sleeve bandages as shown in Fig. 2.

2.6 Exercise-induced muscle soreness [14]

Prior to the exercise session, the same investigator explained and demonstrated the plyometric drop-jump protocol to every participant. After it was fully understood, the same investigator monitored and mastered all steps during the exercise protocol individually. Participants were asked to wear proper sport shoes to reduce load impacted on knee joints. The exercise started with participants standing on a 0.6-meter box, then placing their leading foot slightly outside of the box edge, then dropping down onto the athletic synthetic rubber floor with both feet touching the ground while the knees bend close to 90 degrees (to activate the knee extensor muscle) and then immediately jumping vertically back up into the air as high as possible. Participants were allowed to swing their arms backward, forward, and upward during the jump. Participants were monitored while completing 10 sets of 10 drop-jumps with 10-seconds of rest between each jump and 1-minute of rest between each set. All participants were asked to perform this strenuous exercise during the first day only.

Fig. 2. Tissue flossing band covered around the middle thigh during plyometric exercise.

All participants were instructed to maintain their personal life style and dietary habits but were seriously asked not to use any type of DOMS recovery strategy such as muscle relaxants, oral medications, massage, cold compression/immersion, exercise, or sore muscle stretching in order to prevent the occurrence of confounding factors in the recovery period. Before the experimental testing session, all participants were instructed to abstain from vigorous exercise and consumption of alcohol, energy drinks, or caffeine for at least 48 hours prior to testing, and not to drink for at least 30 minutes prior to, and during, the test.

2.7 Statistical analysis

Research data are shown as mean $\pm$ standard deviation for the pain scale reporting and peak torque of knee extensor. The Shapiro-Wilk test was used to analyze the distribution of data. Due to the small sample sizes, non-normal distribution of dependent variables and all dependent variables were measured at continuous level on three or more different occasions, these conditions may be appropriate for using a non-parametric test. Non-parametric techniques are widely applicable and acceptable for research in the health sciences [25]. The Mann-Whitney U test was then used to analyze any statistically significant differences between the two groups on characteristics of participants. The Friedman test was used to identify differences between and within the groups. The Wilcoxon's signed rank test was used for post-hoc analysis. Statistical analyses were performed using the Statistical Package for Social Science v. 19.0 (IBM SPSS Inc., Chicago, IL, USA). Statistical significance was set at $p < 0.05$ for all analyses.

3. Results and Discussion

3.1 Characteristics of participants

Prior to the exercise-induced muscle soreness, there was no statistically significant difference between groups for participant characteristics as shown in Table1.

Table 1. Characteristics of participants.

Characteristic	TF (n=9)	CON (n=9)
Age (Year)	20.78±1.09	20.44±0.88
Weight (kg)	64.67±7.23	66.67±5.66
Height (cm)	175.33±7.37	173.89±5.78
BMI (kg/m^2)	21.00±1.45	22.03±1.03
GPAQ	388.89±141.11	231.11±275.52

Values are presented as mean ± standard deviation.
No significant difference between groups.
TF: Tissue flossing group, CON: Control group

3.2 Pain scale

Pain scale results for both groups showed a statistically significant increase after induced muscle soreness from before exercise. The severity of soreness in both groups started to rise at 1 hour and peaked at around 48 hours then dropped close to baseline at around 72 hours. Interestingly, the soreness in the TF group appeared to be lower than the CON group during the period of 24-96 hours, mostly around 48 hours after EIMD (Fig. 3); however, there was no statistically significant difference in pain scale reporting between the two groups throughout the study.

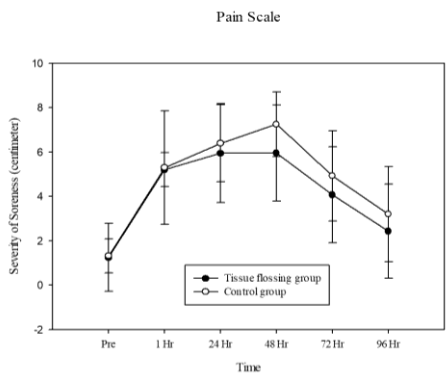

Fig. 3. Change of pain scale after induced muscle soreness (cm).

3.3 Knee extensor peak torque

Peak torque of knee extensor also significantly decreased compared to pre-exercise. Muscle strength started to decline immediately after 1 hour and recovered at around 72 hours (not completely recovered) in a similar fashion throughout the study period in both groups. However, the strength loss in the TF group appeared to be lower than the CON group between hours 1-96 (Fig. 4.); nevertheless, there was no statistically significant difference of peak torque between the two groups throughout the study.

The main outcomes revealed that there was no statistically significant difference between the two groups at each time point throughout the study period with respect to indirect indices of muscle soreness. Mean and standard deviation of pain scale reporting and peak torque of knee extensor of both groups are presented in Table 2. With apparent absence of evidence-based management strategies for band tissue flossing for the prevention of DOMS, this is, to our knowledge, the first study to evaluate the efficacy of applying a modified tissue flossing technique during exercise-induced muscle soreness/damage.

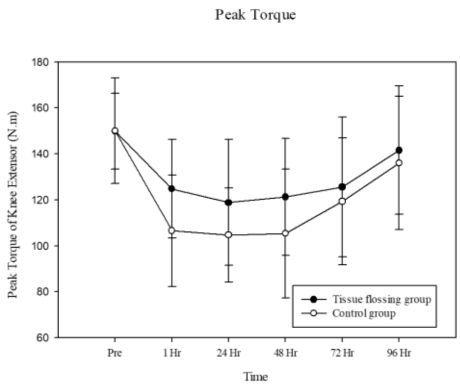

Fig. 4. Change of peak torque after induced muscle soreness (N.m).

Our findings reveal that this type of strenuous exercise eventually results in DOMS, based on the pain scale data that significantly increased, and the peak torque of knee extensor which significantly decreased after the performance of 100 plyometric drop-jumps. This protocol has long been used to induce DOMS in many studies [14, 17] but the true mechanism of DOMS remains unknown. Currently, many researchers hypothesize it to be the ultrastructural damage to muscle cells which leads to further protein degradation, apoptosis, and local inflammatory response [18].

Table 2. Change of indirect indices of muscle soreness.

	Pain scale (cm)			Peak torque (N·m)		
Time	**TF (n=9)**	**CON (n=9)**	**p-value**	**TF (n=9)**	**CON (n=9)**	**p-value**
Pre	1.24±1.53	1.32±0.76	0.441	149.90±16.51	150.12±22.97	0.859
1 Hr	5.21±0.76 †	5.30±2.56 †	0.953	124.83±21.49 †	106.60±24.28 †	0.139
24 Hr	5.95±2.23 †	6.40±1.74 † #	0.722	118.83±27.37 †	104.70±20.44 †	0.214
48 Hr	5.96±2.17 †	7.26±1.45 † #	0.110	121.29±25.43	105.37±28.00 †	0.110
72 Hr	4.07±2.16 †§‡	4.93±2.04 †§‡	0.214	125.60±30.51	119.36±27.57 †§‡	0.594
96 Hr	2.43±2.12 #§‡×	3.20±2.15 #§‡×	0.374	141.59±27.89 #§‡×	136.07±28.93 #§‡×	0.767

Values are presented as mean ± standard deviation. No significant difference between groups. TF, tissue flossing group; CON, control group * Significant difference between groups ($p < 0.05$), † Significant difference to Pre ($p < 0.05$), # Significant difference to 1 Hr ($p < 0.05$), § Significant difference to 24 Hr ($p < 0.05$), ‡ Significant difference to 48 Hr ($p < 0.05$), × Significant difference to 72 Hr ($p < 0.05$).

Pain scale data from both groups was found to significantly increase from the pre-exercise baseline, similar to previous findings of Jakeman et al. (2017); they found that the application of compression garments applied to lower limbs after completing this type of strenuous exercise for 12 hours in young, moderately-active females was shown to reduce the sensation of soreness [14]. Compared to their results (control versus control), participants in this study had suffered from DOMS quite intensely since inclusion criteria required participants to be low-active. Due to the limited number of studies thus far, the results here provide valuable insight on the effects of compression therapy using a floss band during exercise. One of the most promising mechanisms of this type of compression technique may be related to a well-known compression garment. In a study by X. Valle et al, (2013) [8], research was conducted to " evaluate the use of a compression garment as a prevention strategy" during treadmill running with a 10% negative slope; it was found that the damaged muscle of the protected thigh was less injured than the non-protected thigh. This evidence indicated that the " compression garment is an effective method to reduce the histological injury in DOMS" [8]. The compression may help to maintain tissue alignment, reduce muscle oscillation or vibration, muscle displacement, space available for swelling, muscular damage, and sensation of soreness [10, 19]. This implies that compression helps to support muscles during exercise, reducing the strain on load bearing muscles during contraction which may help to reduce the impact of DOMS. These possible mechanisms might also have indirect benefits for perceived soreness since floss bands may stimulate the afferent fibers of skin receptors which are very sensitive to tactile stimuli and further modulate the sensitivity of nociceptors [20]. Furthermore, compression therapy is commonly used in the early phase of rehabilitation programs to reduce inflammation and minimize bleeding into muscles [3, 5, 7]. Additionally, wearing a compression garment affects various perceptual responses and tends to be better or at least not worse than no compression [21]. However, considering immediate responses to acute bouts of exercise, pain scale data at 1 hour showed identical levels of perceived soreness in both groups. This finding may imply that tissue flossing's only benefit is preventing muscle damage via a tissue fascial shearing mechanism rather than modulating or alleviating acute soreness during exercise. As such, the analysis revealed that there was no significant difference between groups even though the application of tissue flossing during exercise appeared to be slightly more effective on reducing severity of soreness in the recovery phase during 24 - 96 hours. It can be assumed that the experience of pain is highly subjective, depending on past experiences of injury and varies largely amongst individuals [22].

Knee extensor peak torque of both groups was found to be significantly decreased from pre-exercise levels, as exercise induced muscle damage typically resulted in an inflammatory response [7, 10]. Pain and swelling are often a source of strength loss in an individual suffering from DOMS [3]. The floss bands seemed to create interface pressure to a higher degree than the force that would be exerted by compression garments. Consequently, the application of tissue flossing during exercise may help to support muscles and prevent them from oscillation/ vibration so that the muscles beneath the compression band were also damaged, but to a lesser degree [18-19]. As such, flossing bands may be used for prevention during exercise as an alternative strategy. Compression may help to prevent influx of inflammatory mediators, chemotaxis, and exudates result in a lower intracellular osmotic pressure that eventually reduces the space available for swelling and decreases the sensitivity of nociceptors to inflammation [13]. Furthermore, a previous study indicated that increased leg volume during exercise can be managed with compression [23]. It should be mentioned that when the floss band was applied during plyometric exercise, it could protect the exercised muscles from fatigue since acute muscle soreness is typically the pain felt in muscles during and immediately after strenuous exercise which is different from DOMS. It was observed that during 1 hour post-exercise, both groups had the same acute muscle soreness level, but the control group showed significant increases in strength loss as DOMS usually peaks at around 24 to 72 hours. Thigh circumference was beyond the scope of our investigation, but recognize that muscle swelling is normally found in DOMS [3]. The floss band that we used in our study was not able to cover the entire surface of the quadriceps femoris muscle, so we only wrapped at the middle part aiming to cover the muscle belly as much as possible. Therefor the upper part and lower parts of the muscle may be predisposed to injury more so than in the middle; this experimental wrapping technique may significantly lead to muscle swelling above and below the covered area [24]. But our results revealed that there was no statistically significant difference between the two groups on strength loss. Nonetheless, a partial wrap of tissue flossing tends to be better or at least not worse than no wrapping. Muscle strength is still a major component for recreation, leisure, and sports activities of athletes. Strength loss may increase their risk of injury during training, resting, and recovery [23].

While it appears that compression therapy offers several potential benefits, we acknowledge that there are some limitations of our study. Firstly, we didn’t calculate the sample size, nor did we account for the anticipated number of dropouts so the sample size is very small. We may have included a disproportionate number of participants which are outliers and anomalies relative to the general population. Hence, a large variation in individual responses to the tissue flossing may ultimately limit the clarity of observed changes or results and proper statistical tests used. With a larger sample size and a more homogenous composition of participants by using a matched pairs parallel group design based on quadricep muscle strength we might find a statistically significant difference between the two groups. Secondly, we had no objective measure of the compression force achieved in our study. It is possible, therefore, that we didn’t achieve consistency of compression in each individual. However, we made attempts to limit potential variations in compression force by ensuring that all wrapping procedures were performed by a single experienced investigator throughout the study. Finally, we could not completely blind the two investigators responsible for wrapping the tissue flossing band and monitoring participants during the exercise session but the investigators responsible for recording study outcome measures were completely blind to all participants and other investigators in order to minimize experimenter bias.

4. Conclusion

The application of a modified tissue flossing technique as a compression strategy during plyometric exercise on prevention of DOMS is either better or not worse than no flossing. Because it is simple, low-cost, practical, and user-friendly, this sport device might be an alternative way to prevent DOMS. Further studies should focus on the pressure force (interface pressure) as well as band size, location, duration, and period of application.

4.1 Clinical implications

- In prevention, treatment, and rehabilitation of delayed-onset muscle soreness (DOMS), compression therapy can be used during and after exercise sessions.
- Tissue flossing may be an innovative strategy for injury prevention, through increasing range of motion (main effect) in musculoskeletal disorders (MSDs).
- The application of a modified tissue flossing technique as a compression strategy during plyometric exercise on prevention of delayed onset muscle soreness tends to be better or not worse than no flossing.

Acknowledgements

We thank the Department of Physical Therapy, Faculty of Allied Health Sciences, Thammasat University in providing the research facility, equipment support, and contributions.

We do gratefully thank all of the participants for their effort and time participating in this research.

Financial support

None reported.

Conflict of interest

All authors report no conflicts of interest relevant to this article.

References

[1] Bogdanis GC. Effects of physical activity and inactivity on muscle fatigue. Front Physiol. 2012; 3:142.

[2] Mueller-Wohlfahrt HW, Haensel L, Mithoefer K, Ekstrand J, English B, McNally S, et al. Terminology and classification of muscle injuries in sport: the Munich consensus statement. Br J Sports Med 2013;47:342-50.

[3] Cheung K, Hume P, Maxwell L. Delayed onset muscle soreness: treatment strategies and performance factors. Sports Med. 2003;33(2):145-64.

[4] Rowlands AV, Eston RG, Tilzey C. Effect of stride length manipulation on symptoms of exercise-induced muscle damage and the repeated bout effect. J Sports Sci. 2001;19(5):333-40.

[5] Connolly DA, Sayers SP, McHugh MP. Treatment and prevention of delayed onset muscle soreness. J Strength Cond Res. 2003;17(1):197-208.

[6] Kraemer WJ, French DN, Spiering BA. Compression in the treatment of acute muscle injuries in sport: review article. Int Sport Med J. 2004;5(3):200-8.

[7] Hill J, Howatson G, van Someren K, Leeder J, Pedlar C. Compression garments and recovery from exercise-induced muscle damage: a metaanalysis. Br J Sports Med 2014;48:1340-6.

[8] Valle X, Til L, Drobnic F, Turmo A, Montoro JB, Valero O, et al. Compression garments to prevent delayed

onset muscle soreness in soccer players. Muscles Ligaments Tendons J. 2013;3(4):295-302.

[9] Goto K, Morishima T. Compression garment promotes muscular strength recovery after resistance exercise. Med Sci Sports Exerc. 2014;46(12):2265-70.

[10] Brown F, Gissane C, Howatson G, van Someren K, Pedlar C, Hill J. Compression Garments and recovery from exercise: a meta-analysis. Sports Med. 2017;47(11):2245-67.

[11] Driller MW, Overmayer RG. The effects of tissue flossing on ankle range of motion and jump performance. Phys Ther Sport. 2017;25(Supplement C):20-4.

[12] Megan H, Keith R, Ethan S, Katie S, Ryan VL. The effects of compression band treatment on muscle recovery after eccentric fatiguing exercise [Color poster with tables, charts, and images]. 2014 [Cited 2019 Jun 29]. Access from: http://digital.library.wisc.edu/1793/71051

[13] Prill R, Schulz R, Michel S. Tissue flossing: a new short-term compression therapy for reducing exercise-induced delayed-onset muscle soreness. a randomized, controlled and double-blind pilot crossover trial. J Sports Med Phys Fitness. 2019;59(5):861-7.

[14] Jakeman JR, Byrne C, Eston RG. Lower limb compression garment improves recovery from exercise-induced muscle damage in young, active females. Eur J Appl Physiol. 2010;109(6):1137-44.

[15] Schomacher J. Gütekriterien der visuellen analogskala zur schmerzbewertung. Physioscience 2008;4:125-33.

[16] Golik-Peric D, Drapsin M, Obradovic B, Drid P. Short-term isokinetic training versus isotonic training: effects on asymmetry in strength of thigh muscles. J Hum Kinet. 2011;30:29-35.

[17] Page W, Swan R, Patterson SD. The effect of intermittent lower limb occlusion on recovery following exercise-induced muscle damage: A randomized controlled trial. J Sci Med Sport. 2017;20(8):729-33.

[18] Hotfiel T, Freiwald J, Hoppe MW, Lutter C, Forst R, Grim C, et al. Advances in Delayed-Onset Muscle Soreness (DOMS): Part I: Pathogenesis and Diagnostics. Sportverletz Sportschaden. 2018; 32(4): 243-50.

[19] Heiss R, Lutter C, Freiwald J, Hoppe MW, Grim C, Poettgen K, et al. Advances in Delayed-Onset Muscle Soreness (DOMS) - Part II: Treatment and Prevention. Sportverletz Sportschaden. 2019;33(1):21-9.

[20] Hassan BS, Mockett S, Doherty M. Influence of elastic bandage on knee pain, proprioception, and postural sway in subjects with knee osteoarthritis. Ann Rheum Dis. 2002;61(1):24-8.

[21] MacRae BA, Laing RM, Niven BE, Cotter JD. Pressure and coverage effects of sporting compression garments on cardiovascular function, thermoregulatory function, and exercise performance. Eur J Appl Physiol. 2012;112(5):1783-95.

[22] Coghill RC, McHaffie JG, Yen YF. Neural correlates of interindividual differences in the subjective experience of pain. Proc Natl Acad Sci U S A. 2003;100(14):8538-42.

[23] Bovenschen HJ, Booij MT, van der Vleuten CJ. Graduated compression stockings for runners: friend, foe, or fake? J Athl Train. 2013;48(2):226-32.

[24] Todd M. Compression bandaging: types and skills used in practical application. Br J Nurs. 2011;20(11):681-2, 4, 6-7.

[25] Tomkins-Lane C. An Introduction to Non-parametric Statistics for Health Scientists. University of Alberta Health Sciences Journal. 2006;3.