ORIGINAL ARTICLE

Comparison of four methods in recovery delayed onset muscle soreness

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ABSTRACT

The aim of the study was to investigate four treatments for the recovery of delayed onset muscle soreness (DOMS). DOMS was induced in 56 women forced by the "*Drop Set*" system and they were divided into four treatment groups: home, massage, proprioceptive neuromuscular facilitation (PNF) and passive stretching. The volunteers answered two pain scales: a numerical scale and a visual analogue scale (VAS) in five stages: 0 h, 24 h, 48 h, 72 h, 96 h and 120 h, before each treatment session. The statistical analysis between the scales and at the different times was carried out using one-way analysis of variance; and the comparison between the groups at the same time was carried out using repeated measures analysis of variance, followed by the Tukey-Kramer post-test. There was no significant difference between the pain measures of the scales. Massage had the lowest pain intensity at 24 and 48 hours compared to the other treatments. Massage is the best method for treating DOMS and passive stretching is the worst. The pain scales are equivalent to each other and could be relevant tools for monitoring recovery from intense physical training.

Keywords: Sport medicine, Massage, Pain measurement, Stretching.

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INTRODUCTION

The delayed onset muscle soreness (DOMS) is a discomfort feeling, which occurs due to some changes in athletes' training or in any non-usual activity that request strength and/or endurance (Thilo Hotfiel et al., 2018). This condition is frequently experienced by all regular physical exercise practitioners, or even by daily life activities. However, sedentary individuals are more likely to feel it more intensely and with longer time, mainly after the practice of movements or intensity they are not accustomed perform (Sadacharan & Seo, 2021).

The DOMS is caused by a muscle structural injury, harm caused in the Z band of sarcomere of muscle myofibrils, increase of sensibility due to oedema and allogenic substances, released post-injury in the muscle fibre and causing inflammatory reaction, local swelling, elevation in white globules count, monocytes' and lymphocytes' buildup and muscle spasms (Douglas et al., 2017). Therefore, present features related to DOMS are: discomfort and skeletal musculature pain a few hours after intense or uncommon physical activity practice, muscle sensibility, severe pain and weakness, loss of strength and movement amplitude, swelling on exercised muscles. These symptoms may reduce athletes' performance and the adhesion of people to strength trainings (Thilo Hotfiel et al., 2018; Sadacharan & Seo, 2021). The eccentric phase of resisted exercise may be the major responsible for the rising of DOMS, due to the muscle is stretched at the same time that should be maintained the cross-bridge cycle intensely, to control the weight loaded, distinct from other muscle actions (Douglas et al., 2017).

It was shown that women are more sensitive and less tolerant than men to the DOMS sensations. However, authors propose that, due to a bigger concentration of oestrogen on women, it acts as a protective effect by its augmented capacity in skeletal muscle receptor de estrogenic-α activation in response to eccentric exercise. It is regulating myogenic-related gene expression, regulating plasticity and muscle mass, this increasing the regeneration process and diminishing the inflammatory response after muscle damage (Haines et al., 2018; McKinley-Barnard et al., 2018). Age is also an important variable, because as years go by, intolerance to pain increases (McKinley-Barnard et al., 2018).

To examine the damages caused to the muscle deriving from strength training, direct methods are used, muscle samples' analysis or exams such as Magnetic Resonance Image; and indirect ones, scales and questionnaires, being these the most used due to its low cost and easiness in execution, especially the pain subjective perception scales (Afridi et al., 2021; Thilo Hotfiel et al., 2018). Regarding a way of training to prevent the DOMS, it hasn't a unique way to prevent this, but the gradual increase in the charge of training is important to reduce this situation.

Several interventions are inquired in order to diminish or DOMS after eccentric physical exercise, including by means of medication, which in high dosages might cause addiction (Gergin et al., 2019; Hotfiel et al., 2018). Primary treatment has been widely advocated to include the Protection, Rest, Ice (Cold), Compression and Elevation (the acronym "*PRICE*"), despite the lack of any high-quality studies to support its evidence (Heiss et al., 2019; Hotfiel et al., 2018).

However, strategies such as regular practice of physical exercises and stretching, from which the passive method, stretching by proprioceptive neuromuscular facilitation (PNF) and massage are highlighted, as resources that may alleviate the DOMS symptoms without harming the organism. Therefore, in this study we compared the response in DOMS recovery in four ways: the massage, proprioceptive neuromuscular facilitation (PNF), passive stretching and resting as a control in sedentary women submitted to arm flexion.

MATERIALS AND METHODS

Subjects

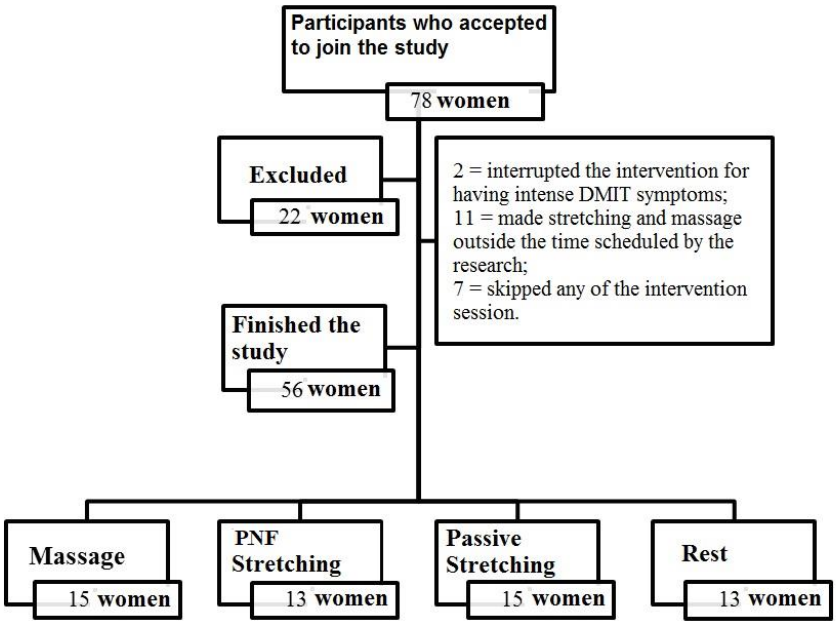
We selected young women, sedentary for at least six months, aged 18–26-year-old with body mass index (BMI) between 18,5 and 30 kg/m² to participate the present study. The voluntaries were not supposed to present any kind of joint injury, acute or chronic inflammatory processes (arthritis, arthrosis, muscle-joint injuries) or any kind of injury that might hinder the execution of free, complete movements. They were not supposed to use any anti-inflammatory drug or muscle relaxant or being pregnant either. All of them signed the consent form to participate the study, approved by the Research ethics committee from "*Cep-Saúde*" (Process n. 5.709.528/CEP-SAÚDE-UFMT/2022).

An exclusion criterion was the use of any intervention besides the ones scheduled in the study, including the usage of any kind of anti-inflammatory such as drugs, gels, ointments, adhesives, massage treatment or stretching in times other than the intervention or the used of hot-water bottle, ice and those who did not attend to the intervention.

Before beginning the intervention, the load of the eccentric test was established by the maximum repetition test (1RM) in the biceps curl exercise to each one volunteer. Weight progression varied from ½ to 1 kg per trial, until it reaches the maximum load possible to be lifted with the maximum of five trials, and the interval of rest from one trial to the other was of three minutes (Lau, Blazevich, Newton, Wu, 2015).

Study design

Seventy-eight women participated the study; however, 22 voluntaries were excluded due to the following reasons: two interrupted the intervention by experiencing heavy symptoms of DOMS, eleven made stretching's and massage outside the time established by the research protocol and seven skipped to any session of intervention. Thus, 56 women finished the study: massage group (n = 15), PNF stretching group (n = 13), passive stretching group (n = 15) and rest group (n = 13) (Figure 1).



Note. Interventions and evaluations lasted for 5 days; PNF = Proprioceptive neuromuscular facilitation.

Figure 1. Experimental design.

Interventions

The voluntaries were divided into four groups according to protocols, being: massage; PNF stretching, passive stretching; and rest group being the control one, as described below:

Massage protocol

Manoeuvres were made in the front part of the forearm, on the biceps muscle and spreading to the front deltoid, being made three kinds of manoeuvres: superficial sliding with fingers, deep sliding with fingers and the digital kneading by using the thumbs. Manoeuvres in each muscle was made in two minutes for superficial sliding, three minutes for deep sliding and three minutes for digital kneading.

PNF stretching protocol

Stretching were made in a way to prioritize the musculature of the elbows' flexors, especially biceps and brachial. It was made with 10 seconds for the passive stretching phase, 10 seconds of isometric contraction at the stretched position and more 10 seconds of passive stretching, totalizing 30 seconds repeated in 02 series.

Passive stretching protocol

It was made by leading the voluntary to the final position of her movement amplitude (ADM in Portuguese) (light pain), and keeping this position for 30 seconds, being that the stretching were made in two series of 30 seconds. The intensity of isometric contraction was approximately 60% of the maximum.

Rest protocol

They only responded to the questionnaires, with no other kind of intervention. At the first day of intervention (0 h) all voluntaries underwent the biceps curl exercise to cause DOMS using an 8 kg bar and ½ kg and 1 kg rings. This exercise was made using the adjusted/helped Drop-Set system, with emphasis on the eccentric phase on biceps muscle beginning at 80% of 1-RM, being decreased the weight in 20% at each muscle failure, until it remains only 20% of 1-RM until total muscle failure, which consisted of no longer controlling the eccentrical phase of muscular contraction. After the 1-RM, the voluntaries were split by simple random raffle, composing the groups with the respective protocols, massage, PNF stretching, passive stretching and rest. After exercise (0 h) the voluntaries waited five minutes to receive the first training session according to the group they belonged to. This treatment was repeated in 24h, 48h, 72h and 96h. On the sixth day (120 h), the voluntaries only responded the questionnaires, without intervention.

DOMS evaluation

The questionnaires of pain used were the Analogical Visual Scale (AVS) and the Numeric Scale (NS), in the following moments: before interventions (0, 24, 48, 72 and 96 hours) and on the sixth day, post-intervention (120 hours) (Afridi et al., 2021).

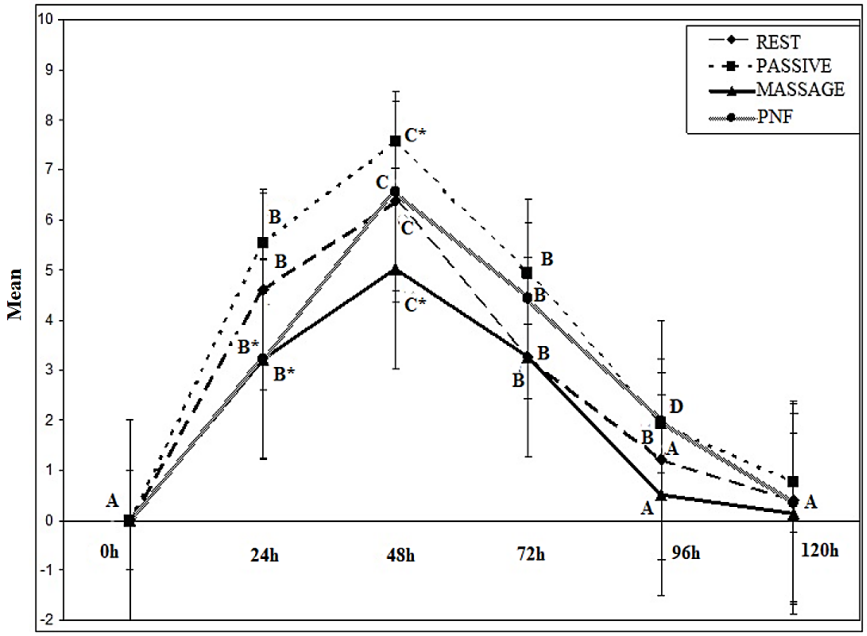
Statistical analysis

Results are presented as average and standard deviation. For comparison of the different moments inside the same group was method of Variance Analysis for Repeated Measures, non-paired. The statistical significance was considered with $p < .05$ and confidence interval of 95%.

RESULTS

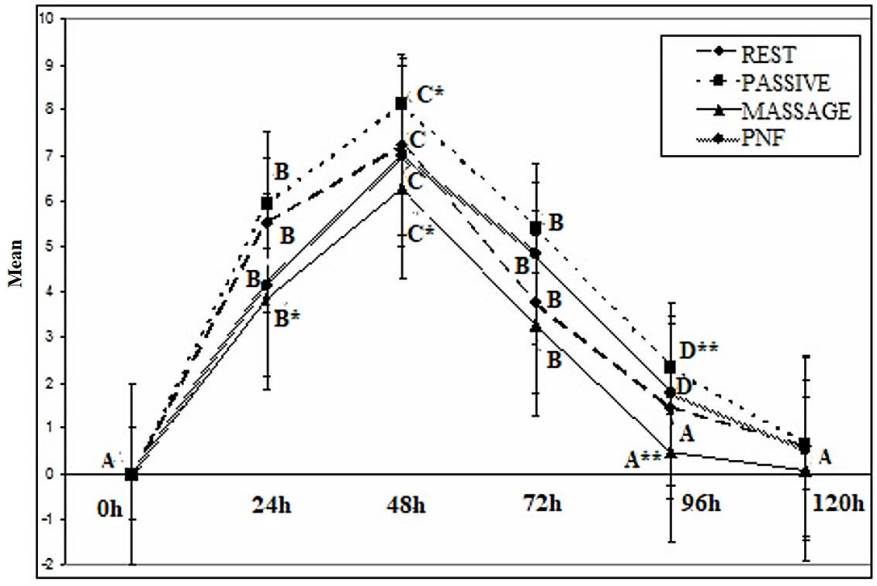
In comparison to the same moment between the two pain scales, VAS and NS, not significantly differences among them was found. Comparing the groups on the same moments, we found significant difference

between massage and passive stretching and between passive stretching and rest in 24h and 48h on EVA, and between passive stretching and the massage in 24h, 48h and 96h on NS (Figures 2 and 3).



*Note. Passive = passive stretching. PNF = proprioceptive neuromuscular facilitation. Letters (A, B, C and D) compare moments at each training and equal letters show that there is not significantly difference (p > .05). * indicate statistical difference between variables at the same moments (p < .05).*

Figure 2. Average and standard deviation of Visual Analogue Scale (VAS) of the volunteers after muscular exhaustion training in different moments.



*Note. Passive = passive stretching. PNF = proprioceptive neuromuscular facilitation. Letters (A, B, C and D) compare moments at each treatment and same letters indicate that there is no meaningful difference. * and ** indicate statistical difference between variables at the same moments (p < .05) and (p < .01), respectively.*

Figure 3. Average and standard deviation of Pain Numeric Scale (NS) of the volunteers after muscular exhaustion training in different moments.

DISCUSSION

When compared at the same moments between groups and for the same group in different moments, results obtained between the scales, NS and VAS, were equivalent for DOMS evaluation which analyse only the pain intensity variation (Afridi et al., 2021). The only differences observed were that NS, in 24h, 48h and 96h moments, presented smaller significantly values for massage, compared to passive stretching; VAS, by its turn, presented differences between 24 and 48h for massage compared to passive stretching and for PNF and compared to the passive stretching at the 24h moment.

The exercise protocol probably caused injuries in the musculature, because symptoms were observed, such as pain, swelling, rigidity, loss of strength, difficulties in performance in daily living activities such as brushing hair and carrying objects. However, there were no major risks or immediate damages and in long term, and after some days, they came back to basal values. The local of major intensity of pain was next to the insertion of biceps muscle, extending also to the forearm, as already seem in another study (Lau, Blazevich, Newton, Wu, 2015).

Two cases of more severity of DOMS were verified among voluntaries who did not finish the intervention period, undergoing some treatment to minimize the symptoms such as usage of anti-inflammatory and massage. To this observed fact, one must take into account the individuality once all volunteers were undergone to the same procedures of maximum protocol, in order to assure all of them would respond to the rising of DOMS (Nahon, Silva Lopes, 2021).

In other studies, the DOMS peak was 48 hours after exercise (Hedderson et al., 2020; Lee et al., 2015), similar to our results. However, Fleckenstein et al (2017) observed that there was no significant difference in DOMS between 24 to 48 hours. In another study, the decrease in DOMS occurred 72 hours after exercise (Lee et al., 2015), corroborating our findings.

From a physiological point of view, the micro-injuries in the Z band induced by resistance training occur in the first week of training, and protein synthesis initially serves to repair these damages. However, from the third week of training, the microlesions are attenuated, however, with protein synthesis causing an increase in sarcomeres in series (muscle hypertrophy) (Damas et al., 2016). Perhaps, this adaptation explains why DOMS is usually caused in the first few sessions. Another possible physiological explanation for this phenomenon is pro-inflammatory and anti-inflammatory cytokines (IL-6 and IL-10) that have high concentrations 48 hours after the first training session, which may play a role in DOMS (Hedderson et al., 2020).

In our study, massage appeared to be the best method for DOMS recovery. In other studies, massage appeared to be an effective treatment in reducing DOMS in ultramarathon runners (Visconti et al., 2015) and fighters (Demirhan et al., 2015). In this context, it has been suggested that massage helps to decrease cytokine levels, which in turn can minimize the inflammatory response expected by exercise (Nelson, 2013).

With regard to DOMS studies of women, a recent review study noted that 77 studies (63.6%) included men only, 13 studies (10.7%) women only, and 31 studies (25.6%) included both sexes (Nahon, Silva Lopes, 2021). In this sense, it can be observed that there are few studies that analyse DOMS in women. We speculate that DOMS caused by physical exercise may be one of the causes of women's low adherence to resistance exercises.

The lack of biochemical data, especially regarding the creatine kinase (CK) anti-inflammatory and pro-inflammatory cytokines concentration, is a limitation of our study, which we intend to include on the next one. Still, the loss of volunteers reduces statistical power. In favour, the main physical performance measurer is the pain perception, which limits the participation in further activities. The present protocol is of hard adhesion for non-athlete people, who are an important public for this kind of investigation, once they are more susceptible and have smaller tolerance to DOMS, compared to trained individuals.

CONCLUSION

The massage protocol used in this study proved itself effective on DOMS reduction throughout the days following the intense exercise session, distinguishing itself to the passive stretching, PNF and rest. PNF stretching was the second-best treatment for DOMS. Both scales of pain evaluation used proved themselves equivalent as for the DOMS intensity evaluation and could be relevant instrument to follow up intense physical training recover. We recommend the inclusion of ice baths in future DOMS-related studies.

AUTHOR CONTRIBUTIONS

Michelle Jalousie Kommers: Writing of the results and writing of the manuscript. Jonatas Deivyson Reis da Silva Duarte: Writing of the results and writing of the manuscript. Waléria Christiane Rezende Fett: Writing of the project and design of the study. Lauriane Cristina da Silva Rocha: Writing of the project, data collection and intervention. Camila Fernanda Costa e Cunha Moraes Brandão: Writing of the project, data analysis and writing of the results Carlos Alexandre Fett: Writing of the project and design of the study.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

DATA AVAILABILITY STATEMENT

Data available on request.

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