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Comparison of Massage Techniques in Preventing Delayed Onset Muscle Soreness among Futsal Players

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Abstract

Purpose. This study aimed to assess the effect of a combination of effleurage with shaking vs. effleurage with tapotement on DOMS.

Material & Methods. A randomized controlled trial was conducted on 30 participants, randomly assigned to the effleurage with tapotement massage group (n=10), the effleurage with shaking massage group (n=10), and the control group (n=10). Participants conducted high-intensity circuit training incorporating eccentric contraction movements to induce DOMS. The knee joint flexion ROM was assessed using a goniometer while CK was evaluated with blood serum and determined using the UV kinetic methods. Muscle soreness was assessed using a pain numeric rating scale (NRS). All measurements were conducted 8 hours after the exercise, immediately following treatment, and 24 hours after treatment. The data were analysed using One-way Repeated Measures ANOVA, one-way ANOVA, Friedman and Kruskall-Wallis tests.

Results. The study revealed that all three groups initially displayed a rise in creatine kinase levels post-treatment, followed by a decline at 24 hours after treatment. Muscle soreness significantly decreased in both treatment groups immediately and after 24 hours, while the control group experienced a notable increase. Both treatment groups also exhibited a substantial increase in knee joint range of motion, as opposed to the control group, which demonstrated a decrease.

Conclusions. The application of both massage combinations showed efficacy in reducing, preventing, and managing DOMS compared to the non-treatment.

Keywords: massage, DOMS, creatine kinase, ROM, muscle soreness, futsal.

Introduction

Futsal is a sport that enjoys significant popularity among the general population due to its dual benefits of promoting physical health and providing enjoyable entertainment. Futsal is a team-based sporting activity characterized by two teams, each consisting of five individuals. Futsal is a sport that requires robust cardiovascular and muscular endurance due to its high-intensity nature, characterized by explosive movements and repeated maximum sprint attempts throughout the game (Naser et al., 2017).

Futsal necessitates the simultaneous utilization of technical and physical skills, resulting in the activation of various muscle groups. This dynamic engagement leads to continuous eccentric contractions, contributing to post-futsal muscle damage that may cause damage manifesting as muscle pain (Bueno et al., 2020). In general, participation in futsal can result in post-competition fatigue, leading to the development of Delayed Onset Muscle Soreness (DOMS). Additionally, the in-tense nature of the game, characterized by excessive muscle contractions, can lead to elevated levels of blood lactate and creatine kinase. The DOMS, furthermore, can negatively impact a joint range of motion and diminish muscle strength (Chou et al., 2021; Contrò et al., 2016; Kalai-

selvan et al., 2017; Nelson, 2013; Zondi et al., 2015).

The cause of DOMS is unclear, but theories include metabolic waste build-up, muscle spasms, and microtrauma. The metabolic waste theory says lactic acid accumulation leads to pain. Muscle spasm theory suggests ischemia causes spasms hindering blood flow. Microtrauma theory indicates exercise-induced microfiber damage and inflammation, causing gradual muscle pain (Cheung et al., 2003; Connolly et al., 2003; Lewis et al., 2012). Recent studies indicate that DOMS involves microscopic muscle injuries leading to inflammation, resulting in muscle soreness, reduced range of motion (ROM), and elevated creatine kinase (CK) levels, often caused by intense physical activity and sports with excessive eccentric muscle contractions (Hedayatpour et al., 2018; Kindermann, 2016; Serinken et al., 2013; Sinaga et al., 2021). The onset of DOMS usually appears around 8 hours after physical activity, which causes DOMS symptoms to become more intense and peak within 24-48 hours before gradually decreasing and usually disappearing within 96 hours (Plowman & Smith, 2014).

Growing evidence indicates that massage therapy is beneficial in managing and preventing DOMS. Considerable emphasis, however, has been placed on investigating the preventative benefits (Andersen et al., 2013). Massage therapy has been suggested as a potential intervention for removing accumulated extracellular fluid in compromised muscles to reduce the incidence of edema and pain by promoting blood and lymph flow (Kargarfard et al., 2016). Furthermore, massage therapy offers many advantages, including reducing muscle tension and pain, enhancing blood circulation, improving flexibility and range of motion, augmentation of nerve conductivity, hormonal alterations, improving the immune system, and facilitating the elimination of chemicals such as blood lactate or creatine kinase (Hunt et al., 2019; Poppendieck et al., 2016).

A study by Naderi et al. (2021) elucidates that massage techniques such as effleurage, petrissage, and vibration effectively alleviate the symptoms of exercise-induced muscle damage. Moreover, it accelerates the recovery process and reinstates the balance of muscles, reducing the likelihood of post-exercise accidents. Recovery is facilitated by enhanced blood circulation to the tissues, which aids in preventing blood clots, diminishing inflammation, alleviating muscle soreness, enhancing flexibility and muscle temperature, and mitigating the effects of DOMS (Sefton et al., 2010; Wiltshire et al., 2010). Additional researchers, as shown by Boguzewski et al. (2015), also reported that sliding, effleurage, rubbing, kneading, and vibration expedite the healing process and enhance the effectiveness of muscles after exercise due to their analgesic properties. The study conducted by White et al. (2020) reveals that the combination of massage therapy using effleurage techniques and neurolymphatic activation aids in reducing systemic inflammatory signals following high-intensity intermittent exercise. Therefore, massage therapy is potential for managing exercise-induced inflammation in athletes after high-intensity intermittent exercise.

Tapotement is an additional massage method that accelerates the process of healing by stimulating the skin tissue and superficial muscles. This technique is particularly beneficial for athletes as it aids in their preparation for competition (Mckechnie et al., 2007). Behm et al. (2013) added that the tapotement technique aims to stimulate sensory receptors (mechanoreceptors). Furthermore, a comprehensive analysis of existing research conducted by Lorna et al (Lorna et al., 2023) revealed that using massage guns in percussive therapy can effectively enhance acute muscular strength, explosive muscle strength, and flexibility while mitigating musculoskeletal pain. It is because percussive therapy utilizing massage guns is believed to replicate the benefits of tapotement massage therapy. Consistent with the findings of the study conducted by Rogers et al. (2020) which investigated the impact of a 10-minute percussion massage on the quadriceps 48 hours after exercise (consisting of 10 sets of 10 back squats), the comparison was performed on the same individuals and lacked control groups. Percussion massage yielded an essential decrease in pain and a notable enhancement in vertical jump performance compared to the participants' baseline measures taken before the percussion massage, 48 hours after exercising. The application of percussion massage impacts the strength of echoes and the skin temperature in the thoracolumbar area of healthy adult males, as observed in a study conducted by Yang et al., (2023). Furthermore, percussive massage enhances blood circulation in the peripheral areas (Rusciano & Woods, 2023).

Shaking or Vibration is an additional method employed in massage therapy to facilitate the recuperation of muscles. The process of muscle healing is contingent upon the circulation of blood. Consequently, applying any shaking or vibration approach will enhance blood circulation, thereby expediting the healing process through increased oxygen supply, regulating muscle temperature, and reducing tissue damage caused by waste chemicals (Barnes et al., 2012). In addition, Kamandani et al. (2013) state that whole-body vibration therapy has physiological effects that enhance the function of both the central and peripheral nervous systems. It stimulates motor

units, reduces the threshold of the Golgi organ, prevents antagonistic muscle activity, activates gamma motor units, and stimulates muscle spindles. Consequently, the oscillation of the body tissue can induce muscular relaxation, enhance tissue pliability, and optimize nerve function.

To date, the roles of massage techniques which include effleurage, tapotement and shaking have not been adequately explored in the context of managing and preventing DOMS. Therefore, this study aimed to compare the effect of combination of effleurage techniques with tapotement and a combination of effleurage with shaking on symptoms associated with DOMS.

Material and methods

Study Design and Participants

This study was a randomized controlled experiment in 30 male futsal players of Asian descent (M=17, SD=1.33, range=15-21 years), who were enrolled in secondary education at the high school level. The participants were assigned to three groups using a random allocation method. The initial group consisted of a combination of the effleurage method with tapotement (ET), the subsequent group comprised a combination of the effleurage technique with shaking (ES), and the last group served as a control group without any treatment (C). The selection of subjects was deter-mined by specific inclusion criteria, which included individuals between the ages of 15 and 21, who had not engaged in sports activities within three days before the study, expressed a willingness to adhere to the research protocols until completion, were enrolled as high school students, and actively participated in futsal. Participants excluded from the study were those experiencing illness or injury.

Ethical Consideration

Prior to the commencement of the investigation, all participants were provided with detailed information regarding the study protocols. The research protocol received approval from the Research Ethics Committee of Yogyakarta State University with the reference number T/10/UN34.9/KP.06.07/2023.

Data Collection Procedures and Measures

This outcome measures included creatine kinase, knee joint flexion ROM, and muscle soreness. These measurements were taken at three distinct time points: (1) prior to treatment or 8 hours after high-intensity exercise, (2) immediately after treatment, and (3) 24 hours after treatment. A 30-minute therapy or massage was administered on the lower extremities. The study incorporated high-intensity Circuit Body Weight Training exercises to induce DOMS. The assessment tool employed for quantifying the experience of muscle pain involves the utilization of the Numeric Rating Scale (NRS). A physiotherapist used a goniometer to assess the ROM of knee joint flexion. The assessment of creatine kinase levels using the UV kinetic analysis method following the guidelines provided by the International Federation of Clinical Chemistry and the Germany Society of Clinical Chemistry was conducted in an accredited public laboratory.

Sport massage intervention

The practitioner applied massage techniques in prone and supine positions for 30 minutes. In the prone position, the massage started with the therapist focusing on the thighs, calves, and then the soles of the feet. The duration of the effleurage technique was set at 2 minutes, while tapotement or shaking was performed for 30 seconds, totaling 15 minutes. Next, the participants changed to the supine position, where the same duration and techniques were applied as in the prone position. The force or intensity of pressure modulated the dimensions and thickness of participants' muscles. The massage application involved applying pressure consistently directed toward the heart and maintaining a uniform beat over a specific period. The therapists received training and were required to have certification of expertise.

Data analysis

Data analysis was done using IBM SPSS software (Version 25) with a significance level of 0.05. The Shapiro-Wilk test was used to check the normality of the data. Longitudinal effects are measured using the repeated measures ANOVA test and the one-way ANOVA test if the basic assumptions of normality and homogeneity are met. In contrast, the Friedman and Kruskall-Wallis tests will be used if the basic assumptions are not met, followed by simple effects analysis with Bonferroni correction to compare the two partners.

Results

Repeated Measures ANOVA and Friedman were used to determine the differences between pre-treatment and post-treatment on creatine kinase, range of motion, and muscle soreness after high-intensity exercise, and one-way ANOVA and Kruskall Wallis were used to determine the treatment effects on creatine kinase, range of motion, and muscle soreness after high-intensity exercise. A summary of time effects and treatment effects is presented in Table 1. Table 1 illustrates the estimated marginal means of creatine kinase, range of motion, and muscle soreness by time and treatment.

First, the creatine kinase study results showed a statistically significant difference in the effect of time between each group (p (ET=0.007;

ES=0.000; C=0.007) <0.05). However, there was no statistically significant difference in the treatment effect at any measurement time. The results of the Bonferroni post hoc test in Table 2 show that the first and second measurements in each group experienced a significant increase in CK levels (p (ET=0.00; ES=0.004; C=0.005) <0.05). The control group exhibited a considerable rise compared to the treatment group (which in-volved a combination of effleurage with tapotement and a combination of effleurage with shaking) based on the average value. The first and third measurements did not show significant differences, but each group experienced a decrease in CK levels (p (ET=0.655; ES=0.371; C=0.655) >0.05). The group combining effleurage with shaking experienced a considerable rise and decrease after 24 hours of treatment compared to before treatment, while the group combining effleurage with tapotement experienced a minor decline, even smaller than the control group. Thus, the results of this study show that the combination group of effleurage with shaking had a good effect in overcoming DOMS with indicators of creatine kinase levels compared to the group combining effleurage with tapotement and the control group after 24 hours of treatment.

The results of the Bonferroni post hoc test in Table 2 show CK measurements before treatment between the ET and ES groups (p=0.762), ET and C (p=0.910), ES and C (p=0.705), meaning that they did not show a significant difference in CK levels before treatment. In the second measurement of CK levels, namely immediately after treatment in the ET and ES groups (p=0.597), ET and C (p=0.131) or ES and C (p=0.257), meaning there was no significant difference in CK levels immediately after treatment. In the third measurement of CK levels, namely, 24 hours after treatment in the ET and ES groups (p=0.821), ET and C (p=0.970) or ES and C (p=0.151), meaning there was no significant difference in CK levels 24 hours after treatment.

Second, the results of the study of right knee joint flexion ROM (p= (ET=0.014; ES=0.000; C=0.000) and left knee joint flexion ROM (p= (ET=0.000; ES=0.000; C=0.000) showed that there were differences There was a significant effect of time between each group. From the average value, the ET and ES groups experienced an increase in right and left knee joint flexion ROM, while group C experienced a decrease. Apart from that, table 1 shows no significant difference in the measurements before treatment statistically significant in the effect of treatment at each measurement time on right leg flexion ROM (p=0.430) and left leg flexion ROM (p=0.828). In contrast, at the second and third measurements, there was a statistically significant difference in the treatment effect at each measurement time immediately after treatment on right leg flexion ROM (p=0.001) and left leg flexion ROM (p=0.001) and 24 hours after treatment on right leg flexion ROM (p=0.001) and left leg flexion ROM (p=0.001).

The results of the Bonferroni post hoc test in Table 2 show that measurements of right knee joint flexion ROM before treatment between the ET and ES groups (p=1.000), ET and C (p=0.603), ES and C (p=1.000), meaning that they do not show The differences between the three groups in right

Table 1. Comparative Research Results of 3 measurement stages

Variabel	Time	Group (n=30)						Treatment Effect
		Eff+tap (n=10)		Eff+sha (n=10)		Control (n=10)		
		M	SD	M	SD	M	SD	
CK	1	127.20	122.37	112.90	105.29	132.70	101.86	0.897
	2	240.10	272.07	205.20	118.02	271.70	152.11	0.272
	3	122.50	131.48	86.30	44.43	124.30	67.926	0.805
Time effect		0.007		0.000		0.007		
Right Knee Flexion	1	102.00	22.88	106.00	12.87	112.00	13.58	0.430
	2	120.00	10.37	122.00	6.75	110.20	9.80	0.001*
	3	129.30	7.26	131.60	10.75	74.00	11.01	0.000*
Time effect		0.000		0.000		0.000		
Left Knee Flexion	1	93.50	22.49	95.00	15.64	98.50	17.01	0.828
	2	109.50	17.23	117.50	14.95	83.50	11.32	0.001*
	3	129.50	8.64	131.00	10.75	65.50	10.22	0.000*
Time effect		0.000		0.000		0.000		
Muscle Pain	1	5.20	1.476	5.40	2.119	3.80	1.619	0.099
	2	3.40	2.119	3.40	2.066	5.70	1.252	0.013*
	3	1.60	1.350	1.80	1.476	7.20	1.033	0.000*
Time effect		0.000		0.000		0.001		

Notes. CK= creatine kinase, 1= Before Treatment/ 8 Hours After DOMS Inducing Exercise, 2= Immediately After Treatment, 3= 24 Hours After Treatment, *Significant

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Tabel 2. Pairwise Comparison Based on Treatments

Parameter's Time	Treatment Pairs	P	Mean Difference
Muscle Soreness			
1	ET-ES	0.809	−0.20
	ET-C	0.087	1.4
	ES-C	0.053	1.6
2	ET-ES	1.000	0
	ET-C	0.030	−2.3
	ES-C	0.030	−2.3
3	ET-ES	0.827	0.20
	ET-C	0.000	−5.6
	ES-C	0.000	−5.4
Right Knee Flexion			
1	ET-ES	1.000	−4
	ET-C	0.603	−10
	ES-C	1.000	−6
2	ET-ES	1.000	−2
	ET-C	0.007	9.8
	ES-C	0.001	11.8
3	ET-ES	1.000	−2.3
	ET-C	0.000	55.3
	ES-C	0.000	57.6
Left Knee Flexion			
1	ET-ES	1.000	−1.5
	ET-C	1.000	−5
	ES-C	1.000	−3.5
2	ET-ES	1.000	-8
	ET-C	0.011	26
	ES-C	0.001	34
3	ET-ES	1.000	−1.5
	ET-C	0.001	64
	ES-C	0.000	65.5
Creatine Kinase			
1	ET-ES	0.762	14.3
	ET-C	0.910	−5.5
	ES-C	0.705	−19.8
2	ET-ES	0.597	34.9
	ET-C	0.131	−31.6
	ES-C	0.257	−66.5
3	ET-ES	0.821	36.2
	ET-C	0.970	−1.8
	ES-C	0.151	−38

Notes. ES = Combination of effleurage with Shaking, ET = Combination of effleurage with Tapotement, C = Control Group, 1= Before Treatment/ 8 Hours After DOMS Inducing Exercise, 2= Immediately After Treatment, 3= 24 Hours After Treatment.

knee joint flexion ROM were significant before treatment. In the second measurement of right knee joint flexion ROM, namely immediately after treatment in the ET and ES groups (p=1.000), meaning that there was no significant difference between the ET and ES groups in right knee joint flexion ROM immediately after treatment, ET and C (p=0.007) and ES and C (p=0.001) meaning that there was a significant difference between the ET and C and ES and C groups in right knee joint flexion ROM immediately after treatment. In the third right knee joint flexion ROM measurement, namely 24 hours after treatment in the ET and ES groups (p=1,000), there was no significant difference between the ET and ES groups in the right knee joint flexion ROM 24 hours after treatment. In contrast, ET and C (p=0.000) and ES and C (p=0.000), meaning that there was a significant difference between the ET and C and ES and C groups in right knee joint flexion ROM 24 hours after treatment.

The results of the Bonferroni post hoc test in

Table 2 show that the measurement of left knee joint flexion ROM before treatment between the ET and ES groups (p=1,000), ET and C (p=1,000), ES and C (p=1,000), means that it does not show The differences between the three groups in left knee joint flexion ROM were significant before treatment. In the second measurement of left knee joint flexion ROM, namely immediately after treatment in the ET and ES groups (p=1.000), meaning that there was no significant difference between the ET and ES groups in left knee joint flexion ROM immediately after treatment, ET and C (p=0.011) and ES and C (p=0.001) meaning that there was a significant difference between the ET and C and ES and C groups in left knee joint flexion ROM immediately after treatment. In the third left knee joint flexion ROM measurement, namely 24 hours after treatment in the ET and ES groups (p=1,000), there was no significant difference between the ET and ES groups in left knee joint flexion ROM 24 hours after treatment. In contrast, ET and C (p=0.001) and ES and C (p=0.000), meaning that there was a significant difference between the ET and C and ES and C groups in left knee joint flexion ROM 24 hours after treatment.

Third, the results of the muscle pain study showed a statistically significant difference in the effect of time between each group (p (ET=0.000; ES=0.000; C=0.001) <0.05). In addition, in Table 1, measurements before treatment show no statistically significant difference in the effect of treatment on muscle pain measurements (p= 0.099). In contrast, in the second and third measurements, there is a statistically significant difference in treatment effect on measurements immediately after muscle pain (p=0.013) and 24 hours after treatment for muscle pain (p=0.000).

The results of the Bonferroni post hoc test in Table 2 show measurements of muscle pain before treatment between the ET and ES groups (p=0.809), ET and C (p=0.807), ES and C (p=0.053) did not show differences in muscle pain which was significant before treatment. In the second measurement of muscle pain, namely, immediately after treatment, the ET and ES groups (p=1.000), meaning there was no significant difference in muscle pain immediately after treatment, while ET and C (p=0.030) and ES and C (p=0.030), meaning There was a significant difference in muscle pain between ET and C and ES and C immediately after treatment. The third measurement of muscle pain was 24 after treatment in the ET and ES groups (p=0.827), meaning there was no significant difference in muscle pain 24 hours after treatment, while ET and C (p=0.000) and ES and C (p=0.000), meaning there was a significant difference in muscle pain between ET and C and ES and C 24 hours after treatment.

Discussion

Numerous studies have investigated the impact of sports massage on DOMS following high-intensity training. Limited studies, however, comprehensively DOMS's indicators which include creatine kinase levels, range of motion, and muscle soreness. This study, study has provided a preliminary examination of the therapeutic impacts of effleurage combined with tapotement and effleurage combined with shaking, each administered for 30 minutes, on the lower extremities after high-intensity exercise-induced DOMS. The results of this study suggest that the utilization of a treatment approach involving a combination of effleurage with tapotement and effleurage with shaking is more effective in preventing DOMS compared to no-treatment.

The findings of this study indicate that those who did not receive any treatments exhibited a progressive increase in muscle soreness signs over some time. This observation aligns with the findings from a study indicating that DOMS intensify approximately 8 hours following high-intensity exercise and reaches its peak between 24 to 48 hours (Hotfiel et al., 2018). During this present study, participants who received effleurage combined with tapotement and effleurage combined with shaking experienced a gradual decrease in muscle soreness during the intervention. Massage with manipulation techniques of effleurage and tapotement have also been found to alleviate symptoms of DOMS and increase joint range of motion (Graha et al., 2023). In addition, sports massage is known to have physiological effects on the nervous system, specifically the stimulation of pain and its transmission to the brain, giving rise to tactile stimulation and pain experienced, resulting in reduced perception of pain and slower transmission of pain signals, this phenomenon has been shown to increase the activation of the descending control system. Endorphins and increases muscle relaxation (Ilmi et al., 2018). Similar to the results in this study which used combination massage manipulation techniques, especially a combination of effleurage and shaking, this approach can also relieve muscle pain in the long term. This is due to the manipulative act of effleurage, which involves rubbing and shaking, which creates vibrations, which collectively contribute to the reduction of pain. As a massage maneuver, the effleurage technique reduces muscle tension and pain, promotes relaxation, improves blood circulation, and facilitates lymphatic flow (Gensic et al., 2017; Mueller, 2018; Standley et al., 2010; Yin et al., 2022).

The DOMS which affect legs can lead to reduced ROM flexion in the knee joint. This decrease in ROM is accompanied by increased muscular tension and stiffness, resulting in decreased

muscle flexibility. Consequently, the ability of the joint to move is negatively impacted (Trisnowiyanto, 2017). The findings from the research indicate that the combination of effleurage with tapotement and the combination of effleurage with shaking can decrease muscular tension, alleviate discomfort, and enhance muscle flexibility, leading to improvements in knee joint flexion range of motion (Gasibat & Suwehli, 2017; Gol & Aghamohamadi, 2020). The findings of this study align with a study which demonstrated that massage therapy has the potential to enhance the range of motion and alleviate discomfort (Field et al., 2015). The control group demonstrates muscle rigidity, leading to a reduction in range of motion due to intense training (Lau et al., 2015; Vogt & Hoppeler, 2014).

The findings in this study indicate a notable increase in all three groups' immediate creatine kinase levels following the treatment. That indicates that the treatment group had no immediate impact, whereas the control group had the most substantial increase. Therefore, the intervention employed in this research demonstrates superior efficacy in mitigating the elevation of creatine kinase levels after high-intensity physical exertion. This study's results are consistent with Kargarfard et al research (Kargarfard et al., 2016), indicating that massage therapy had minimal effectiveness, as evidenced by the significantly inferior outcomes in the massage group compared to the control group, and all three groups experienced a decrease in creatine kinase (CK) levels 24 hours post-treatment.

This study showed that the group that underwent the effleurage combination technique with shaking exhibited the most substantial decrease in CK levels. The combination of effleurage and tapotement demonstrated a minor decrease compared to the control group without exhibiting superior results. In this study, it was observed that CK levels reduced even in the absence of treatment. It is important to note that the people included in the study had undergone training and possessed a high level of physical fitness. This factor likely contributed to the accelerated recovery of their bodies (Skorski et al., 2019; Tomlin & Wenger, 2001).

Our findings also found differences in research results with existing theory between comparing the effleurage combination group with tapotement and the control group. In theory, the combination of effleurage with tapotement can affect CK levels (Ilmi et al., 2018). One of the contributing factors to elevated levels of CK is the application of overload training principles in an exercise program, coupled with engagement in unfamiliar forms of exercise. This combination elicits a physiological response called General Adaptation Syndrome (GAS), which describes the body's reaction to exercise-induced stimuli. The GAS encompasses three distinct stages: alarm, resistance, and fatigue (Campbell et al., 2013; Cunanan et al., 2018). Elevated levels of CK exhibit a robust correlation with the existence of submicroscopic muscle damage. Hence, it can be inferred that the cohort subjected to the combined application of effleurage and tapotement exhibited greater elevation in CK levels in comparison to the control group. The observed phenomenon might be ascribed to the potential influence of the effleurage with the tapotement approach, which can exacerbate muscle or soft tissue injury by eliciting excessive muscular contraction and impeding the tissue healing process (Nédélec et al., 2013).

The research exhibits several strengths. The study's randomized controlled design, allocating 30 participants to different massage groups and a control group, enhances internal validity by minimizing selection bias. The relevance of the sample, which underwent high-intensity circuit training with eccentric contraction movements, mirrors real-world conditions where DOMS commonly occurs. Objective outcome measures, including knee joint flexion range of motion, creatine kinase levels, and perception of muscle soreness provide both objective and subjective data. The inclusion of a control group without treatment allows for a baseline comparison, aiding the assessment of specific massage effects on DOMS. Additionally, the study's collection of data at multiple time points offers a comprehensive understanding of temporal effects.

However, several limitations are acknowledged. Firstly, the relatively small sample size may limit generalizability, and larger samples are preferred for statistical power. Secondly the lack of quarantine measures implemented to regulate the subjects' activities, rest periods, sleep quality, and dietary intake throughout the study. Moreover, it is important to highlight that the study specifically enrolled individuals with prior training and focused solely on evaluating muscle soreness indicators, CK levels, and knee joint flexion ROM immediately and 24 hours post-treatment. Consequently, to offer a more comprehensive understanding of the effects of massages on DOMS, longitudinal studies with increased frequency and extended observation periods are necessary.

Conclusions

The research findings demonstrate that applying sports massage with combined effleurage techniques with tapotement and combined effleurage with shaking in sports massage yields positive outcomes in preventing DOMS, indicated by reductions in CK levels and muscular soreness, and improvements in knee joint flexion (ROM).

A combination of effleurage with tapotement and effleurage with shaking has been identified as a practical approach to mitigate the occurrence of DOMS after high-intensity training sessions compared with no treatment.

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