

# Exploring the Benefits of Combined Effleurage and Tapotement Techniques for Alleviating Delayed Onset Muscle Soreness (DOMS) in Futsal Players

Ali Satia Graha<sup>1</sup>, Zanzabil Adwa Fitriani<sup>1,2,\*</sup>, Ahmad Nasrulloh<sup>1</sup>

<sup>1</sup>Department of Sport Science, Yogyakarta State University, Indonesia

<sup>2</sup>Department of Sport Education, Faculty of Teacher Training and Education, Universitas Lambung Mangkurat, Indonesia

Received August 9, 2023; Revised October 16, 2023; Accepted November 14, 2023

## Cite This Paper in the Following Citation Styles

(a): [1] Ali Satia Graha, Zanzabil Adwa Fitriani, Ahmad Nasrulloh, "Exploring the Benefits of Combined Effleurage and Tapotement Techniques for Alleviating Delayed Onset Muscle Soreness (DOMS) in Futsal Players," *International Journal of Human Movement and Sports Sciences*, Vol. 11, No. 6, pp. 1383 - 1390, 2023. DOI: 10.13189/saj.2023.110624.

(b): Ali Satia Graha, Zanzabil Adwa Fitriani, Ahmad Nasrulloh (2023). Exploring the Benefits of Combined Effleurage and Tapotement Techniques for Alleviating Delayed Onset Muscle Soreness (DOMS) in Futsal Players. *International Journal of Human Movement and Sports Sciences*, 11(6), 1383 - 1390. DOI: 10.13189/saj.2023.110624.

Copyright©2023 by authors, all rights reserved. Authors agree that this article remains permanently open access under the terms of the Creative Commons Attribution License 4.0 International License

**Abstract** This study aims to determine the effect of a combination of effleurage techniques with tapotement on DOMS with indicators of muscle pain, ROM, and creatine kinase levels. This study used experimental methodology using a pretest-posttest control group design. Participants were divided into two groups: the treatment and control groups. Data was collected twice, 8 hours after exercise and immediately after treatment. The DOMS-inducing exercise in this study was circuit training. The sample methodology used in this study utilized a purposive sampling technique guided by specific inclusion and exclusion criteria. The aim was to select 20 futsal players. The present study employed various data-collecting instruments, such as a Visual Analogue Scale (VAS) for pain evaluation, a Goniometer for quantifying knee joint flexion, and laboratory analysis for ascertaining creatine kinase levels. The findings from this study suggest that the use of effleurage techniques combined with tapotement after high-intensity exercise, which affects the occurrence of delayed-onset muscle soreness (DOMS), provides good results in preventing DOMS by reducing muscle soreness, increasing range of motion (ROM), and suppressing elevated levels of creatine kinase in the bloodstream.

**Keywords** Effleurage, Tapotement, Massage, DOMS, Futsal

## 1. Introduction

Sport is a form of physical activity characterized by repetitive body motions, primarily enhancing one's physical fitness. Sports have become a habit and necessity for every individual because physical activity done correctly and adequately can continuously improve one's physical fitness. Regular exercise is the most effective maintenance endeavor and a component of efforts to prevent directly from one's health factors. Furthermore, sports serve to attain physical health and foster accomplishment. Sports, in general, are beneficial for the body to maintain and increase independence in human life but can also adversely affect the body and cause injuries. [1].

Futsal is often regarded as a highly favored sporting option in society [2]. Futsal is a sport characterized by high-intensity activities that involve eccentric movements, which have the potential to induce muscular injury and physical stress, often stated as Delayed Onset Muscle Soreness (DOMS) [3]. Sports with high intensity, such as futsal games, needed intensive training to support players' performance to play optimally. Therefore, it is necessary to have high-intensity training to get maximum performance in playing, but intense training can cause damage to the muscles [4].

Delayed-onset muscle soreness (DOMS) is a condition that manifests as muscular discomfort, tenderness, and

reduced range of motion, typically emerging about 8 hours following physical activity. The symptoms progressively intensify, peak within 24–48 hours, and usually resolve within 96 hours [5]–[7]. Muscle damage resulting from physical exertion can lead to Delayed Onset Muscle Soreness (DOMS), characterized by diminished muscular strength, limited range of motion (ROM), and localized edema [8]. Lima and Denadai [9] provide another perspective, stating that exercise-induced muscle injury has the potential to augment both muscular pain and impair movement functionality. Other research conducted by Sitompul et al [10] found that intensive exercise will cause muscle pain and tissue damage with increased blood lactate and creatine kinase levels. The same opinion was also expressed by Kalaiselvan et al [11] suggesting that the pain that arises when Delayed onset muscle soreness (DOMS) occurs due to engaging in eccentric exercise, which induces damage to the membranes of muscle cells. This damage then initiates an inflammatory response, impairing specific functioning muscles and reducing joint motion or range of motion (ROM). Additionally, muscular injury incites the release of the enzyme Creatine Kinase (CK) [12]. Muscle damage from exercise will cause pain and loss of muscle function that appears immediately up to 14 days after exercise [13]. Evidence that DOMS has damaged muscle cell membranes is the occurrence of changes in the sarcolemma or phospholipid membrane due to microdamage to skeletal muscle where the sarcolemma loses its ability to retain potassium, creatine kinase, and myoglobin, which are released into the extracellular fluid, plasma, and urine [14]. Proper treatment when DOMS arises can be treated with soaked ice therapy, full body massage, PNF stretching, and warm therapy [15].

Therefore, the treatment approach employed in this study to mitigate the occurrence of Delayed Onset Muscle Soreness (DOMS) involves administering massage therapy, utilizing a combination of effleurage methods and tapotement. Massage is the mechanical manipulation of body tissue with rhythmic pressure such as effleurage, petrissage, shaking, tapotement, walking, friction, and stroking [16] and aims to improve fitness, preparation before exercise, prevention and rehabilitation of injuries [17]. This statement is supported by Priyonoadi et al. [18] that massage has benefits for the body, namely being able to reduce muscle tension, reduce muscle pain, improve blood circulation, increase flexibility, range of motion, nerve conductivity and hormonal changes, as well as increase immunity and cleanse substances such as blood lactate or creatine kinase. The use of a combination of effleurage massage techniques with tapotement helps to increase blood circulation because gentle stroking movements and rhythmic strokes will help the flow of blood rich in nutrients and oxygen, which will quickly improve the recovery of damaged muscle tissue, increase muscle relaxation, and increase flexibility [19].

The main aim of this study is to examine the effects of massage therapy with a mix of effleurage techniques and

tapotement on variables such as range of motion (ROM), creatine kinase levels, and muscle soreness to prevent Delayed Onset Muscle Soreness (DOMS). This research specifically focuses on individuals engaged in high-intensity exercise and exercises involving eccentric contractions.

## 2. Materials and Methods

### 2.1. Participants

The study focuses on a specific group, namely futsal players from SMAN 1 Banjarmasin. The study included 20 futsal players selected using purposive sampling techniques. The inclusion criteria for the sample were as follows: participants had to be between the ages of 15–21 years, not engaged in any sports activities for three days before the study, willing to fully comply with the research procedure, enrolled as students at SMAN 1 Banjarmasin, and actively involved in futsal practice. According to the exclusion criteria, individuals currently experiencing illness or injury and those not engaged in resistance activity for at least six months are not eligible for participation. The participants were randomly allocated into groups, each consisting of ten individuals.

### 2.2. Procedure

The research employed a pretest-posttest control group design. The selected study investigated the potential impact of administering a combined effleurage treatment with tapotement on preventing Delayed Onset Muscle Soreness (DOMS).

The treatment group was subjected to an intervention consisting of massage therapy utilizing a combination of effleurage methods and tapotement. In comparison, the control group was not subjected to any type of intervention or treatment. The massage therapy group employed a combined technique of effleurage and tapotement, administered 8 hours following workouts that induced delayed onset muscle soreness (DOMS). The massage specifically targeted the lower limbs and lasted for 30 minutes. Therapeutic interventions are administered in the prone and supine positions, targeting both lower extremities. The treatment commences with the patient assuming a prone posture, followed by using effleurage techniques on the thighs, calves, and soles of the feet. Each segment receives a 2-minute length of effleurage, followed by a 30-second tapotement. The subsequent phase involves maintaining a supine position for the same duration. The research instruments employed in this study encompass goniometers, visual analog scales (VAS), and laboratory analysis utilizing IFCC procedures. The investigation was conducted in March 2023 at the Borneo Indoor Futsal Banjarmasin field in South Kalimantan Province.

The data collection methodology employed in this study consisted of two distinct phases. The first phase involved collecting data eight hours after the DOMS inducer training, serving as the pretest data. The second phase involved collecting data immediately after the participants received treatment, serving as the post-test data. Before measuring the pretest, the subjects first carried out DOMS-inducing exercises in the form of circuit training exercises. The circuit training workouts utilized to produce Delayed Onset Muscle Soreness (DOMS) comprise a series of 10 stations with equal work and rest periods, with each interval lasting 30 seconds. The inter-set recovery period is set at 3 minutes, and the total number of sets performed is 3. The data was collected through tests and measurements after obtaining a research permit from the South Kalimantan Provincial Education and Culture Office (Permit No. 043//SMA/Disdikbud/2023). After obtaining the comprehensive data, conducts data analysis to answer the research hypothesis.

### 2.3. Data Analysis

Data analysis using software SPSS Version 26. The stages in data analysis include describing research variables. These prerequisite tests include normality and homogeneity tests, followed by hypothesis testing using paired t-tests if prerequisite tests are met. Wilcoxon Signed Rank Test is used if prerequisite tests are not met, comparisons between the two groups using independent sample t-test if prerequisites are met, and Mann Whitney u-test is used if prerequisites are not met.

### 2.4. Ethics

This research protocol has been deemed ethically sound following seven WHO 2011 standards: 1) Social values, 2) Scientific values, 3) Equitable appraisal and benefits, 4) Risks, 5) Persuasion/exploitation, and 6) Confidentiality and privacy. 7) Informed Consent, citing the CIOMS 2016 guidelines. The fulfillment of indicators for each standard demonstrates this. The Research Ethics Commission for the Institute for Research and Community Service, Yogyakarta State University, has ratified the Ethics Declaration with number No.T/10/UN34.9/KP.06.07 /2023.

## 3. Result

This study aims to investigate the impact of a combined treatment that incorporates the effleurage method and tapotement in preventing Delayed Onset Muscle Soreness. Before doing hypothesis testing in research, it is customary to perform precursor tests, including normality and homogeneity tests. The normality test results are presented in Table 1, while the homogeneity test results can be found in Table 2.

**Table 1.** Normality Test

Test of Normality				
	Shapiro-Wilk			
	Treatment Group		Control Group	
	Sig.	Decision	Sig.	Decision
Creatine Kinase (Pretest)	.014	Abnormal	0.070	Normal
Creatine Kinase (Posttest)	.002	Abnormal	0.005	Abnormal
Muscle Pain (Pretest)	.514	Normal	0.005	Abnormal
Muscle Pain (Posttest)	.443	Normal	0.102	Normal
FLKA (Pretest)	.123	Normal	0.609	Normal
FLKA (Posttest)	.543	Normal	0.028	Abnormal
FLKI (Pretest)	.292	Normal	0.554	Normal
FLKI (Posttest)	.331	Normal	0.125	Normal

This study conducted a normality test, followed by a homogeneity test using the Levene test. The choice regarding homogeneity was based on the significance value, with a threshold of 0.05. The homogeneity test results are presented below.

**Table 2.** Homogeneity Test

Test of Homogeneity of Variance		
	Sig.	Decision
Creatine Kinase (Pretest)	0.636	Homogen
Creatine Kinase (Posttest)	0.235	Homogen
Muscle Pain (Pretest)	0.710	Homogen
Muscle Pain (Posttest)	0.321	Homogen
FLKA (Pretest)	0.697	Homogen
FLKA (Posttest)	0.418	Homogen
FLKI (Pretest)	0.350	Homogen
FLKI (Posttest)	0.160	Homogen

Following initial assessments in this study, the researchers conducted subsequent hypothesis testing. Statistical techniques, including the paired t-test and Wilcoxon Signed Rank Test, were utilized to determine the treatment's effects. Additionally, they utilized an independent t-test or Mann-Whitney U-test to compare the two groups. The subsequent findings from the research on

Delayed Onset Muscular Soreness (DOMS) indicators, including Range of Motion (ROM), muscular discomfort, and creatine kinase levels, are illustrated as follows in Table 3.

Based on table 3. The results of this study demonstrate a statistically significant distinction ( $p < 0.05$ ) in the levels of creatine kinase before and after the intervention when comparing the treated group to the control group. This suggests that the intervention impacted the creatine kinase levels in both groups. The study's findings indicate that both groups exhibited a statistically significant alteration in creatine kinase levels following the intervention. Based on the mean values, it can be shown that each group exhibited elevated levels of creatine kinase. The analysis of creatine kinase levels between the two groups revealed that the obtained p-value of greater than 0.05 indicates a lack of statistical significance, suggesting no substantial distinction between the two groups. However, when examining the average posttest scores of both groups, it is evident that although both groups saw an increase after receiving treatment, the average increase observed in the group that received a combination of effleurage and tapotement was lower than the control group. Therefore, utilizing a mix of effleurage techniques in the treatment group demonstrates superior efficacy in mitigating the occurrence of delayed onset muscle soreness (DOMS), as seen by the reduction in creatine kinase levels following high-intensity physical exertion.

Based on table 4. The treatment and control groups obtained the value of Sig.  $< 0.05$  in the pain or pain scale means a significant difference exists between the pretest and posttest pain treatment and control groups. However, judging from the average difference between the posttest and the pretest, the treatment group experienced a decrease

in pain, while the control group experienced an increase in pain. The comparison between the two groups of pain showed the value of Sig.  $< 0.05$ , there is a significant difference between the two groups. Thus, the results of the comparison of the two groups showed that the combined treatment of the effleurage technique with tapotement had a better effect in overcoming pain than no treatment at all, so it can be concluded that the combination treatment of the effleurage technique with tapotement influences preventing pain.

Based on table 5, significant values were obtained for the range of motion (ROM) flexion of the knee joints in both the right and left legs of the treatment group and the control group. A p-value of less than 0.05 indicates a statistically significant difference in the knee joint's range of motion (ROM) between the pretest and posttest measurements. The experimental group exhibited increased range of motion (ROM) flexion of the knee joint, as indicated by the pretest and posttest assessments. On the other hand, the control group demonstrated a reduction in range of motion (ROM). Therefore, applying a combination of effleurage techniques with tapotement impacts the range of motion (ROM) of knee joint flexion during treatment. Significant differences were seen in the range of motion (ROM) of knee joint flexion between the two groups. When the p-value is less than 0.05, it indicates a statistically significant difference between the two groups. The analysis of the outcomes from both groups revealed that applying the effleurage technique in conjunction with tapotement resulted in a significant enhancement in the expansion of the range of motion (ROM) compared to the absence of any therapy. Hence, the concurrent application of the effleurage technique and tapotement has a beneficial effect on improving the range of motion (ROM) in knee joint flexion.

**Table 3.** Comparison of the Average Scores of Both Groups in preventing DOMS with indicators of creatine kinase levels after high-intensity exercise

		Pretest	Posttest	p value*
		Mean $\pm$ SD	Mean $\pm$ SD	
Creatine Kinase	Treatment Group	122.5 $\pm$ 31.48	240.1 $\pm$ 272.07	0.028
	Control Group	132.7 $\pm$ 101.86	271.7 $\pm$ 152.11	0.007
	p value**	0.131		
*Paired T-test or Wilcoxon Signed Ranked Test				
**Independent Sample T-test or Mann Whitney U-test				

**Table 4.** Comparison of the Average Scores of Both Groups in preventing DOMS with indicators of muscle pain after high-intensity exercise

		Pretest	Posttest	p value*
		Mean $\pm$ SD	Mean $\pm$ SD	
Muscle pain	Treatment Group	5.2 $\pm$ 1.48	3.4 $\pm$ 2.12	0.005
	Control Group	3.8 $\pm$ 1.62	5.7 $\pm$ 1.25	0.011
	p value**	0.008		
*Paired T-test or Wilcoxon Signed Ranked Test				
**Independent Sample T-test or Mann Whitney U-test				

**Table 5.** Comparison of the Average Scores of Both Groups in preventing DOMS with indicators of ROM Knee Flexion after high-intensity exercise

		Pretest	Posttest	p value*
		Mean±SD	Mean±SD	
ROM FLKA	Treatment Group	102.00±22.88	112.00±13.58	0.050
	Control Group	120.00±10.37	100.20±9.80	0.020
	p value**	0.002		
ROM FLKI	Treatment Group	93.50±22.49	109.00±18.38	0.002
	Control Group	98.50±17.01	87.50±12.30	0.036
	p value**	0.007		
*Paired T-test or Wilcoxon Signed Ranked Test				
**Independent Sample T-test or Mann Whitney U-test				
FLKA = Flexion of the right knee joint				
FLKI = Flexion of the right knee joint				

As a result, the study findings indicated that the implementation of a therapeutic regimen consisting of a combination of effleurage techniques and tapotement proved to be successful in reducing the incidence of delayed onset muscle soreness (DOMS). This was evidenced by decreased creatine kinase levels, muscular pain alleviation, and improved range of motion in the lower extremities, particularly in knee joint flexion.

#### 4. Discussion

The findings of this study suggest that implementing a combined intervention involving effleurage techniques and tapotement effectively mitigates the occurrence of delayed onset muscle soreness (DOMS). Delayed Onset Muscle Soreness (DOMS) manifests muscular damage from high-intensity or atypical physical activity. This condition is typified by reduced joint mobility, the onset of muscular discomfort, and elevated creatine kinase levels [20]. Some of the exercises that cause DOMS is high-intensity exercise and exercises that cause eccentric muscle contractions [21]. Eccentric exercises cause muscle contractions to lengthen, such as running downhill, squats, and push-ups [22].

The findings of this study indicate the effect of a combination of effleurage techniques with tapotement on DOMS indicators, namely muscle pain, ROM, and creatine kinase. In the control group, pain after high-intensity exercise increased because pain due to exercise is one of the indicators of DOMS, which occurs after high-intensity exercise and will increase over time [20]. The cause of pain is due to the body's response in repairing tissue damage caused by high-intensity exercise so that the pain will arise due to stimulation of the sensory nerve endings [23]. Apart from increasing pain, high-intensity exercise also triggers a decrease in joint range of motion or what is commonly called ROM. Trisnowiyanto et al [24] have revealed that delayed onset muscle soreness (DOMS) affects the

muscular system, increasing muscle tension and stiffness. Consequently, this loss in muscle flexibility might impede the range of motion in the joints. As stated by Massidda et al. [25], muscle versatility refers to the ability of a muscle to undergo elongation or facilitate the movement of a single joint across a spectrum of motion.

Whereas in the Treatment Group, an effleurage intervention combined with tapotement can reduce symptoms of DOMS and increase the range of motion of joints [26]. Other research revealed by Ilmi et al [27] explains that sports massage manipulation with various techniques, one of which is effleurage with tapotement, can reduce muscle pain after eccentric activity, which causes DOMS due to the physiological effects of sports massage, which affects the nervous system so that influence pain stimulation to the smaller brain. Applying effleurage and tapotement techniques during massage therapy can have physiological benefits expedited and enhance blood circulation, facilitating the delivery of oxygen and nutrients to the muscles experiencing pain. Additionally, it can aid in removing residual substances, reducing tension in the affected muscles. The alternating stimulation of strikes and subsequent relaxation of the muscles can contribute to pain relief. This is attributed to the release of endorphins, which act as natural pain relievers, ultimately reducing pain perception and promoting a sense of comfort and relaxation [28].

In addition to having an effect on pain after high-intensity exercise, the administration of a combination of effleurage and tapotement techniques can reduce muscle tension and pain and increase muscle flexibility so that the ability to move joints changes for the better [29]. Massage can also increase the limitations of joint motion after physical exercise; this is because massage can relieve pain and tension, increase flexibility, relax the body, and accelerate recovery after exercise [30], [31]. The results of this study are also in line with the results of research by Field et al [32] that giving massage can increase the range

of motion and reduce pain levels. Other research revealed by Juwita [33] that massage is effective for reducing pain levels because there are strokes on the body that help to calm and relax the muscles and will release endorphins which cause a feeling of comfort in the body. Administering a combination of effleurage technique manipulation with tapotement physiologically will help increase body temperature, increase proprioception, increase connective tissue elasticity, which will stimulate the production of collagen and elastin in the connective tissue around the muscles, and will trigger a response in the muscles and the nervous system to become relaxed so that it will increase muscle flexibility that raises responsiveness to the range of motion in the joints [34]. The findings of this study align with the research conducted by Priyonoadi et al [35] which suggests that massage therapy can benefit individuals by alleviating post-exercise muscular discomfort and improving overall mobility capabilities.

In this study, creatine kinase levels increased significantly in both groups, meaning that the treatment did not have a significant effect. The causative factors for the presence of DOMS with high indicators of creatine kinase in the control group are due to the principle of workload training in the exercise program and forms of exercise that are foreign to the subject [20]. But this is, according to Campbell et al [36] and Cunanan et al [37] in applying progressive and overload involving a stimulus, the human body's reaction to a stimulus due to exercise is commonly called the General Adaptation Syndrome (GAS). GAS describes how the body responds to stress and involves three stages: alarm, resistance, and exhaustion. Thus, the gas phase will cause the body to decrease function and pain that arises due to exercise.

Another factor that causes DOMS to occur is that the indicator of creatine kinase levels is still high in the effleurage group with the tapotement that when DOMS occurs or increases in creatine kinase levels, the muscles are damaged, therefore according to Nédéc et al [38] that the potential effect than the effleurage technique with tapotement exacerbate muscle or soft tissue injuries because it can cause excessive muscle contraction and damage to the tissue that is recovering. In contrast, the effleurage technique is recommended for use in recovering or injured muscles because it can help improve blood circulation and reduce inflammation.

Although in this study, creatine kinase levels increased significantly in both groups, compared to the posttest values of the two groups, it showed that the Treatment Group gave a smaller increase. This indicates that there is a positive effect of giving a combination of effleurage with tapotement due to the physiological effect of being able to increase blood flow, thereby cleaning up waste substances such as blood lactate and creatine kinase [17]. Another opinion expressed by Yuniana et al. [39] is that massage improves blood circulation, speeds up the recovery process, removes burning residue, and spreads nutrients to tissues.

According to the study's findings, using a combination

of effleurage and tapotement techniques has been shown to have a preventive effect on delayed onset muscle soreness (DOMS). This effect is achieved through many mechanisms, including enhancing the range of motion (ROM), alleviating discomfort, mitigating muscle pain, and inhibiting a lesser elevation in creatine kinase levels compared to the control group.

## 5. Conclusions

According to the findings of the research, administering a treatment involving a combination of effleurage techniques and tapotement after high-intensity physical activity, which is known to induce delayed onset muscle soreness (DOMS), yields favorable outcomes in terms of mitigating the occurrence of DOMS. This treatment approach exhibits positive effects by reducing muscle pain, enhancing range of motion (ROM), and suppressing elevated creatine kinase levels in the bloodstream.

## Conflicts of Interest

The author affirms that there are no potential conflicts of interest in this paper's research, authorship, and publication.

## Acknowledgements

The authors express their gratitude to the research participants for their participation in the study, as well as to Yogyakarta State University for their valuable support.

## REFERENCES

- [1] M. A. Elmagd, "Common Sports Injuries," *Int. J. Phys. Educ. Sport. Heal.*, vol. 3, no. 5, pp. 142–148, 2016, [Online]. Available: <https://www.kheljournal.com/archives/?year=2016&vol=3&issue=5&part=C&ArticleId=599>
- [2] D. Windoro, A. Kristiyanto, and S. Riyadi, "Decision Making Tactics of Indonesian Futsal Women Goalkeepers," *Int. J. Adv. Soc. Econ.*, vol. 2, no. 2, pp. 60–65, 2019, doi: 10.33122/ijase.v2i2.152.
- [3] A. D. Juniarsyah, T. Apriantono, and I. K. Adnyana, "Karakteristik Fisiologi Pemain Futsal Profesional Dalam Dua Pertandingan Berturut-Turut," *J. Sains Keolahragaan dan Kesehatan*, vol. 2, no. 2, p. 31, 2017, doi: 10.5614/jskk.2017.2.2.1.
- [4] T. Barranco *et al.*, "Changes in creatine kinase, lactate dehydrogenase and aspartate aminotransferase in saliva samples after an intense exercise: A pilot study," *J. Sports Med. Phys. Fitness*, vol. 58, no. 6, pp. 910–916, 2018, doi: 10.23736/S0022-4707.17.07214-0.
- [5] S. A. Plowman and D. L. Smith, *Exercise Physiology For*

*Health, Fitness, And Performance*, 4th ed. Lippincott Williams & Wilkin, 2014.

- [6] R. L. Nahon, J. S. Silva Lopes, and A. Monteiro de Magalhães Neto, "Physical therapy interventions for the treatment of delayed onset muscle soreness (DOMS): Systematic review and meta-analysis," *Phys. Ther. Sport*, vol. 52, pp. 1–12, 2021, doi: 10.1016/j.ptsp.2021.07.005.
- [7] V. Sethi, "Literature review of Management of Delayed onset muscle soreness (DOMS)," *Int. J. Biol. Med. Res. Int J Biol Med Res*, vol. 3, no. 1, pp. 1469–1475, 2012.
- [8] J. M. Peake, O. Neubauer, P. A. D. Gatta, and K. Nosaka, "Muscle damage and inflammation during recovery from exercise," *J. Appl. Physiol.*, vol. 122, no. 3, pp. 559–570, 2017, doi: 10.1152/jappphysiol.00971.2016.
- [9] L. C. R. Lima and B. S. Denadai, "Attenuation of eccentric exercise-induced muscle damage conferred by maximal isometric contractions: a mini review," *Front. Physiol.*, vol. 6, no. OCT, pp. 1–7, Oct. 2015, doi: 10.3389/fphys.2015.00300.
- [10] G. G. Sitompul, A. Sinulingga, and R. Dewi, "Kandungan Buah Bit (Beta Vulgaris L) Dalam Peningkatkan Daya Tahan V02 Max Pada Atlet Futsal," in *Prosiding Seminar & Conference Nasional Keolahragaan*, 2021, pp. 3–6.
- [11] A. Kalaiselvan, K. M., and S. M.V, "Effect of proprioceptive neuromuscular facilitation versus Muscle energy technique in improving muscle Function in delayed onset muscle soreness In recreational players," *Int. J. Pharma Bio Sci.*, vol. 8, no. 3, pp. 26–30, Jul. 2017, doi: 10.22376/ijpbs.2017.8.3.b901-911.
- [12] Z. H. Kanik, S. Citaker, C. Y. Demirtas, N. C. Bukan, B. Celik, and G. Gunaydin, "Effects of Kinesio Taping on the Relief of Delayed Onset Muscle Soreness: A Randomized, Placebo-Controlled Trial," *J. Sport Rehabil.*, vol. 28, no. 8, pp. 781–786, 2019, doi: 10.1123/jsr.2018-0040.
- [13] D. J. Owens, C. Twist, J. N. Copley, G. Howatson, and G. L. Close, "Exercise-induced muscle damage: What is it, what causes it and what are the nutritional solutions?," *Eur. J. Sport Sci.*, vol. 19, no. 1, pp. 71–85, Jan. 2019, doi: 10.1080/17461391.2018.1505957.
- [14] M. A. Cleary, M. R. Sitler, and Z. V Kendrick, "Dehydration and Symptoms of Delayed-Onset Muscle Soreness in Normothermic Men," *J. Athl. Train.*, vol. 41, no. 1, pp. 36–45, 2006.
- [15] Y. Prihantoro and R. L. Ambardini, "Prevalensi, Karakteristik, Dan Penanganan Delayed Onset Muscle Soreness (Doms)," *MEDIKORA*, vol. 17, no. 2, pp. 126–135, Dec. 2018, doi: 10.21831/medikora.v17i2.29184.
- [16] A. W. Kurniawan and M. T. A. Kurniawan, *Sport Massage : Pijat Kebugaran Olahraga*, I. Tulungagung: Akademia Pustaka, 2021. [Online]. Available: <http://fik.um.ac.id/wp-content/uploads/2021/10/eBook-Sport-Massage.pdf>
- [17] W. Poppendieck, M. Wegmann, A. Ferrauti, M. Kellmann, M. Pfeiffer, and T. Meyer, "Massage and Performance Recovery: A Meta-Analytical Review," *Sport. Med.*, vol. 46, no. 2, pp. 183–204, 2016, doi: 10.1007/s40279-015-0420-x.
- [18] B. Priyonoadi, P. Sutapa, and A. S. Graha, "Sports Massage to Improve the Immunoglobulin A (Iga) and the Hormon Beta Endorphin," in *Proceedings of the 3rd Yogyakarta International Seminar on Health, Physical Education, and Sport Science in conjunction with the 2nd Conference on Interdisciplinary Approach in Sports*, 2019, no. 1, pp. 704–709. doi: 10.5220/0009801807040709.
- [19] Samsudin, *Ilmu Lulut*. Jakarta: UNJ Press, 2018.
- [20] T. Hotfiel *et al.*, "Advances in Delayed-Onset Muscle Soreness (DOMS): Part I: Pathogenesis and Diagnostics," *Sport. Sport.*, vol. 32, no. 04, pp. 243–250, Dec. 2018, doi: 10.1055/a-0753-1884.
- [21] W. Y. Lau, A. J. Blazevich, M. J. Newton, S. S. Xuan Wu, and K. Nosaka, "Assessment of muscle pain induced by elbow-flexor eccentric exercise," *J. Athl. Train.*, vol. 50, no. 11, pp. 1140–1148, 2015, doi: 10.4085/1062-6050-50.11.05.
- [22] M. O. Harris-Love, J. M. Gollie, and J. W. L. Keogh, "Eccentric exercise: Adaptations and applications for health and performance," *J. Funct. Morphol. Kinesiol.*, vol. 6, no. 4, 2021, doi: 10.3390/jfmk6040096.
- [23] Y. E. Putri, A. Triansyah, W. Y. Ningrum, and M. F. Bafadal, "Sport Massage dan Stretching Dalam Mengurangi Delayed Onset Muscle Soreness Olahraga Intensitas Tinggi," *J. Performa Olahraga*, vol. 7, no. 2, pp. 98–103, 2022, doi: 10.24036/jpo326019.
- [24] B. Trisnowiyanto, "Pengaruh Mat Pilates Exercise Terhadap Fleksibilitas Tubuh," *J. Kesehat.*, vol. 9, no. 2, p. 40, 2017, doi: 10.23917/jurkes.v9i2.4583.
- [25] M. Massidda, N. Miyamoto, S. Beckley, N. Kikuchi, and N. Fuku, *Genetics of flexibility*. Elsevier Inc., 2019. doi: 10.1016/B978-0-12-816193-7.00013-0.
- [26] O. Dupuy, W. Douzi, D. Theurot, L. Bosquet, and B. Dugué, "An evidence-based approach for choosing post-exercise recovery techniques to reduce markers of muscle damage, Soreness, fatigue, and inflammation: A systematic review with meta-analysis," *Front. Physiol.*, vol. 9, no. APR, Apr. 2018, doi: 10.3389/fphys.2018.00403.
- [27] M. A. Ilmi, B. Purwanto, and D. Tinduh, "Pengaruh Manipulasi Sport Massage Terhadap Intensitas Nyeri Setelah Aktivitas Eksentrik," *J. Biosains Pascasarj.*, vol. 20, no. 2, p. 66, Sep. 2018, doi: 10.20473/jbp.v20i2.2018.66-71.
- [28] A. S. Graha, *Massage Terapi Cedera Olahraga*, Pertama. Yogyakarta: UNY Press, 2019.
- [29] Q. Gasibat and W. Suwehli, "Determining the Benefits of Massage Mechanisms: A Review of Literature," *Artic. J. Rehabil. Sci.*, vol. 2, no. 3, pp. 58–67, 2017, doi: 10.11648/j.rs.20170203.12.
- [30] M. Behringer, D. Jedlicka, and J. Mester, "Effects of lymphatic drainage and cryotherapy on indirect markers of muscle damage," *J. Sports Med. Phys. Fitness*, vol. 58, no. 6, pp. 903–909, 2018, doi: 10.23736/S0022-4707.17.07261-9.
- [31] A. Zebrowska, R. Trybulski, R. Rocznik, and W. Marcol, "Effect of Physical Methods of Lymphatic Drainage on Postexercise Recovery of Mixed Martial Arts Athletes," *Clin. J. Sport Med.*, vol. 29, no. 1, pp. 49–56, 2019, doi: 10.1097/JSM.0000000000000485.
- [32] T. Field, M. Diego, G. Gonzalez, and C. G. Funk, "Knee

- arthritis pain is reduced and range of motion is increased following moderate pressure massage therapy,” *Complement. Ther. Clin. Pract.*, vol. 21, no. 4, pp. 233–237, 2015, doi: 10.1016/j.ctcp.2015.08.002.
- [33] L. Juwita, “Literature Review: Pengaruh Massage Therapy Terhadap Nyeri Persalinan Kala Satu,” *J. Ners Lentera*, vol. 7, no. 2, pp. 114–129, 2019, [Online]. Available: <http://journal.wima.ac.id/index.php/NERS/article/view/2115>
- [34] Y.-R. Yeun, “Effectiveness of massage therapy on the range of motion of the shoulder: a systematic review and meta-analysis,” *J. Phys. Ther. Sci.*, vol. 29, no. 2, pp. 365–369, 2017.
- [35] B. Priyonoadi, J. Ndayisenga, P. Sutopo, and A. S. Graha, “Immunoglobulin-A (IgA) improvement through sports and frirage massage,” *Int. J. Hum. Mov. Sport. Sci.*, vol. 8, no. 5, pp. 271–282, 2020, doi: 10.13189/saj.2020.080516.
- [36] T. S. Campbell, J. A. Johnson, and K. A. Zernicke, “General Adaptation Syndrome BT - Encyclopedia of Behavioral Medicine,” M. D. Gellman and J. R. Turner, Eds. New York, NY: Springer New York, 2013, pp. 842–844. doi: 10.1007/978-1-4419-1005-9\_1135.
- [37] A. J. Cunanan *et al.*, “The General Adaptation Syndrome: A Foundation for the Concept of Periodization,” *Sport. Med.*, vol. 48, no. 4, pp. 787–797, 2018, doi: 10.1007/s40279-017-0855-3.
- [38] M. Nádéc, A. McCall, C. Carling, F. Legall, S. Berthoin, and G. Dupont, “Recovery in Soccer,” *Sport. Med.*, vol. 43, no. 1, pp. 9–22, Jan. 2013, doi: 10.1007/s40279-012-0002-0.
- [39] R. Yuniana, Tomoliyus, B. W. Kushartanti, N. I. Arovah, and A. Nasrulloh, “Effectiveness of massage therapy continued exercise therapy against pain healing, ROM, and pelvic function in people with chronic pelvic injuries,” *J. Phys. Educ. Sport*, vol. 22, no. 6, pp. 1433–1441, 2022, doi: 10.7752/jpes.2022.06180.