

The Effect of Massage Therapy on Preventing Delayed Onset Muscle Soreness (DOMS) in Sprinters

Wiwit Azmi Lestari*, Ratna Wardani, Haryono Haryono

Faculty of Public Health, Universitas Strada Indonesia, Kediri, Indonesia

Corresponding author: azmivanus@gmail.com

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ABSTRACT

Sports significantly contribute to students' physical and mental development, enhancing fitness and social skills. However, high-intensity training, such as sprinting, often results in Delayed Onset Muscle Soreness (DOMS), which can impair athletic performance and motivation. Massage manipulation therapy is a physiotherapeutic approach aimed at preventing and alleviating DOMS symptoms while increasing the Range of Motion (ROM) and reducing muscle pain in sprinter athletes at SMAN 91 Jakarta. This quasi-experimental study employed a pre-test and post-test design with three groups: ESK (effleurage, shaking, kneading, $n=15$), ESH (effleurage, shaking, hacking, $n=16$), and a control group ($n=13$). Interventions were administered once weekly over four weeks. ROM was measured using a goniometer, and muscle soreness was assessed via the Visual Analog Scale (VAS). Data were analyzed using the Kolmogorov-Smirnov and Shapiro-Wilk tests for normality, the Friedman test, and further analysis using the Kruskal-Wallis test for within-group differences. The ESK group showed a significant reduction in muscle soreness from a mean of 3.48 to 1.91 ($p<0.005$), while the ESH group exhibited a significant improvement in ROM from a mean of 1.56 to 3.06 ($p<0.005$). The control group showed no statistically significant changes in either variable. Massage manipulation therapy was effective in reducing muscle pain and enhancing ROM. ESH was more effective for improving ROM, whereas ESK was more effective for reducing pain. These findings emphasize the importance of combining multiple Massage techniques for comprehensive physiotherapy benefits in school-based athletic training.

INTRODUCTION

Sports activities contribute significantly to students' physical growth, mental development, and social skills. According to the World Health Organization (2019), regular physical activity helps prevent various diseases and improves quality of life. Athletics is one of the most popular sports among students, offering opportunities for practice and competition. Data from the Centers for Disease Control and Prevention (CDC) indicate that about 2.6 million children and adolescents in the US suffer sports-related injuries annually, particularly to the knee and ankle. In Indonesia, the importance of sports is reinforced by Law No. 3 of 2005 on the National Sports System and Law No. 20 of 2003 on the National Education System, which mandate physical education as a compulsory subject and emphasize the role of teachers in developing sports in schools (Pemerintah Republik Indonesia, 2003; 2005).

Complaints of SMAN 91 student-athletes involved in athletic clubs often experience muscle tension, limited joint motion, and muscle pain after intensive training. According to the National Collegiate Athletic Association (NCAA), injuries occur due to participation in training or competition. Research shows that the most common body parts injured in student-athletes at the college and high school levels are the hip/thigh/upper leg (17.5%) and hand/wrist (18.2%) (Kerr et al., 2017). The emergence of fatigue and muscle pain after training, known as delayed Onset Muscle Soreness (DOMS), is a common condition and has been widely discussed in the literature. DOM usually arises from eccentric activities rarely performed or performed at high intensity (Connolly et al., 2003)

DOMS usually occurs within 24-48 hours after intense exercise and causes stiffness, pain, and muscle swelling. This happens due to damage to microscopic changes in muscle fibers, especially after eccentric exercise (e.g., downhill running). Signs of DOMS include increased stiffness during passive movement, muscle shortening, swelling, decreased strength and explosive power, impaired proprioception, and pain in certain areas (Proske & Morgan, 2001). Intense physical exercise, especially involving eccentric muscle contractions at high-intensity levels, can result in muscle injury (McEwen et al., 2019). Muscle injury due to exercise can trigger muscle soreness (DOMS), reduce the muscle's ability to produce force and joint range of motion (ROM), and cause swelling in certain areas (Peake et al., 2017).

The mechanism of DOMS involves inflammation and complex biochemical reactions, which can significantly affect an athlete's performance (Cheung et al., 2003). DOMS occurs more often in sports that involve repetitive movements. For the muscles in the lower quadrant, the ones that often experience DOMS are the back, thighs, calves, and feet. Athletes often feel pressured to continue training despite their bodies sending signals of fatigue, which can lead to more serious injuries. Muscle pain occurs in response to tears in muscle fibers, which triggers an adaptation process to maintain muscle strength. Muscle injuries (muscle strains) are generally caused by overtraining, which influences most of the muscle fibers, thus affecting the range of motion and tendon function. Discomfort and muscle disorders can occur due to repeated and continuous exercise without sufficient recovery time (Connolly et al., 2003).

The negative impacts of DOMS not only affect athletic performance but also reduce students' motivation to train. Therefore, effective recovery methods are needed. Massage therapy has been widely recognized as one approach to relieve DOMS symptoms and accelerate muscle recovery, enabling athletes to return to training more optimally. Research shows that massage can reduce post-exercise muscle pain, improve circulation, and increase flexibility and range of motion (Priyonoadi et al., 2020; Weerapong et al., 2005). Specific combinations of techniques such as effleurage, shaking, kneading, and hacking are often applied to relax muscles, reduce tension, and support injury prevention, making massage a relevant intervention for student-athletes experiencing DOMS.

Research conducted by Davis et al. (2020) showed that post-workout massage therapy increases flexibility and reduces delayed onset Muscle Soreness (DOMS) symptoms. However, there is no direct evidence of significant improvements in athletic performance. This study emphasizes the importance of massage therapy as a recovery strategy, especially in overcoming muscle fatigue and improving athlete comfort after exercise. Techniques such as effleurage and petrissage have been shown to accelerate blood circulation and relieve pain, making them relevant in high-intensity exercises such as sprinting.

Another study by Fitrian (2023) comparing the effect of sports massage on preventing DOMS in futsal players also supports previous findings. In the study, combining massage with specific oils effectively reduced quadriceps muscle pain and increased joint range of motion. These findings strengthen the hypothesis that massage manipulation interventions, especially those involving combination techniques, can provide significant therapeutic effects on muscle recovery after eccentric exercise. This is relevant to SMAN 91 Jakarta sprinters who experience muscle pain and limited movement after intense training sessions.

This study aims to comprehensively evaluate the effectiveness of massage manipulation therapy with a combination of effleurage, shaking, and kneading (ESK) techniques, as well as effleurage, shaking, and hacking (ESH) in preventing and treating DOMS symptoms in short-distance runners. The primary focus of this study is to observe the effect of both techniques on increasing the range of motion (ROM) of the lower limbs and reducing the intensity of muscle pain after exercise. This study aims to contribute to the development of practical and applicable physiotherapy interventions in school environments, serving as a reference for the development of student-athletes based on evidence-based practice.

METHOD

This study employed a quasi-experimental research method with a pretest-posttest control group design. The population consisted of student-athletes in the athletics club of SMAN 91,

totaling 50 individuals. The sample size was determined using G*Power 3.1 software, with parameters set at an estimated effect size of 0.5, statistical power of 0.8, significance level of 0.05, and correlation between measurements of 0.5. With three groups and four measurements, the minimum required sample was 30 subjects. To anticipate possible dropouts, the researcher increased the number of participants to 44, all of whom provided informed consent.

The 44 participants were divided into three groups:

1. Treatment Group I (n=15): received massage manipulation therapy using a combination of effleurage, shaking, and kneading (ESK).
2. Treatment Group II (n=16): received massage manipulation therapy using a combination of effleurage, shaking, and hacking (ESH).
3. Control Group (n=13): did not receive massage intervention.

The intervention was conducted once a week for four weeks, with each session lasting 20 minutes. Measurements were carried out before and after treatment to assess two main variables: (1) muscle pain intensity using the Visual Analog Scale (VAS), and (2) range of motion (ROM) of the lower extremities using a goniometer.

Data analysis included the Kolmogorov-Smirnov and Shapiro-Wilk tests to examine data normality, the Friedman test to analyze within-group differences, and the Kruskal-Wallis test to compare effectiveness across groups. Ethical considerations were fulfilled through informed consent from participants and approval from relevant institutions.

RESULTS

Massage therapy to ROM (Range of Motion) in lower legs before and after exercise

Table 1. ROM data normality test

Variable	Statistic	df	Sig. (p)	Normality status
Pre-test ROM	0.94	44	0.02	Abnormal
Post-test ROM 2	0.96	44	0.14	Normal
Post-test ROM 3	0.96	44	0.15	Normal
Post-test ROM 4	0.96	44	0.17	Normal

The data in Table 1 indicates that one data point is not normally distributed. Therefore, the non-parametric Friedman statistical test was used for further analysis.

Table 2. Friedman test data ROM

Mean Rank	
Variable	Mean rank
Pre-test ROM	1.56
Post-test ROM 2	2.55
Post-test ROM 3	2.84
Post-test ROM 4	3.06
Statistics test	
Statistic	Value
N	44
Chi-square	66.27
df	3
Asymp. sig. (p)	0.00

The Friedman test was used to analyze the changes in the ROM score in weeks 1, 2, 3, and 4. The analysis results showed a p-value of 0.000 < 0.005, indicating a change in the weekly ROM score.

Analysis of the effect of giving massage manipulation therapy on pain in the lower legs before and after exercise

Table 3. Normality test of pain data

Variable	Statistic	df	Sig. (p)	Normality status
Pre-test Pain	0.91	44	0.00	Abnormal
Pain Post-test 2	0.89	44	0.00	Abnormal
Pain Post-test 3	0.70	44	0.00	Abnormal
Pain Post-test 4	0.69	44	0.00	Abnormal

Due to the presence of abnormal data, further analysis will employ non-parametric statistical tests, specifically the Friedman test.

Table 4. Friedman test of pain data

Mean rank	
Variable	Mean rank
Pain pre-test	3.48
Pain post-test 2	2.58
Pain post-test 3	2.03
Pain post-test 4	1.91
Statistics test	
Statistic	Value
N	44
Chi-square	74.87
df	3
Asymp. sig. (p)	0.00

The Friedman test was used to analyze changes in pain scores in week 1, week 2, week 3, and week 4. The analysis results showed a p-value of $0.000 < 0.005$, indicating a weekly change in pain scores.

Effectiveness of massage manipulation therapy using different combinations of techniques, compared to the control group, in improving ROM in the lower limbs before and after exercise

Table 5. Kruskal-Wallis' test for comparative effectiveness of manipulation Massage therapy in increasing ROM

Mean rank per group		
Group	N	Mean rank
ESH therapy group	16	30.41
ESK therapy group	15	27.07
Control group	13	7.50
Total	44	-
Statistics test		
Statistic	Value	
Chi-square	27.08	
df	2	
Asymp. sig. (p)	0.00	

Based on the mean rank table, the Kruskal-Wallis test is used to determine whether there is a significant difference between three or more groups, thereby assessing whether there are significant differences in effectiveness among the three groups. The ESH therapy group has the highest ROM improvement, followed by ESK therapy, and the Control Group with the lowest effectiveness. Then, the results of the Kruskal-Wallis statistical test, the Asymp. sig. (p-value) = $0.000 < 0.05$, then there is a significant difference in effectiveness between the three groups.

Comparative analysis of the effectiveness of manipulation massage therapy with a technique combination with a control group in overcoming muscle pain in the lower legs before and after exercise

Table 6. Kruskal-Wallis' test for comparative effectiveness of the manipulation massage therapy combination in reducing pain

Mean rank per group		
Group	N	Mean rank
ESH therapy group	16	29.19
ESK therapy group	15	27.93
Control group	13	8.00
Total	44	–
Statistics test		
Statistic	Value	
Chi-square	24.71	
df	2	
Asymp. sig. (p)	0.00	

The ranks table shows the average rank value (mean rank) of each group. The ESK therapy group has the best effectiveness in reducing pain (highest rank), followed by ESH therapy and the control, which has the lowest effectiveness.

From the test statistics table information, the results of the Kruskal-Wallis test show that the p-value data obtained is $0.000 < 0.05$, so there is a significant difference in the effectiveness of therapy for pain. Between three groups. Mean rank of each group. The ESK therapy group had the highest effectiveness in reducing pain (highest rank), and the ESH therapy and control group had the lowest effectiveness.

DISCUSSION

The effect of manipulation massage therapy using a combination of effleurage, shaking, and kneading techniques on lower-limb Range of Motion (ROM) before and after exercise

Massage manipulation therapy using techniques such as effleurage, shaking, and kneading involves mechanical stimulation of body tissue through rhythmically applied pressure and stretching. This process enhances muscle flexibility and joint mobility by improving blood circulation, reducing muscle tension, and promoting coordination and recovery of muscle tissue (Prentice, 2024; Wiyoto, 2011).

These findings highlight the importance of ROM as a key indicator of athletic performance, especially in sprinting, where optimal lower-limb mobility directly improves speed and efficiency. This is consistent with Mahesvi et al. (2023), who reported that massage therapy, particularly effleurage, is effective in reducing muscle tension during ankle injury rehabilitation.

Overall, the results and supporting theories provide evidence that massage manipulation therapy, combining effleurage, shaking, and kneading, is efficacious in improving ROM in young sprinters. The significant week-to-week improvements not only enhance performance but also help prevent injuries caused by limited mobility. Therefore, it is recommended that this therapy be incorporated into the regular training programs of short-distance runners to improve physical capacity and support competition readiness.

In addition, the study emphasizes the importance of continuous monitoring and periodic evaluation of joint and muscle function through ROM assessments. Such evaluations can assist coaches and physiotherapists in designing more targeted and effective interventions, particularly for young athletes in the developmental stage of achieving optimal performance.

Analyzing the effects of manipulation massage therapy using a combination of effleurage, shaking, and kneading techniques on lower-limb muscle pain before and after exercise

Theoretically, massage therapy using effleurage, shaking, and kneading techniques is known to relieve muscle pain by increasing blood circulation, improving tissue metabolism, and stimulating nerve receptors that inhibit pain transmission (gate control theory) (Melzack & Wall, 1965). Massage also helps reduce muscle tension and local inflammation, thereby lowering pain perception. This aligns with Fitriani (2023), who reported that massage manipulation with techniques such as effleurage and tapotement reduces post-exercise pain after eccentric activity through its physiological effects on the nervous system. By stimulating both touch and pain receptors simultaneously, massage slows pain signal transmission, produces a distraction effect, and enhances endorphin release, leading to muscle relaxation.

According to Prentice (2024), massage can have both reflexive and mechanical effects. For example, effleurage, performed with slow and rhythmic movements, provides relaxation through sensory and motor nervous system stimulation. Shaking improves venous and lymphatic circulation, reduces muscle tension, and supports nervous system function. Meanwhile, kneading helps reduce lactic acid accumulation in muscle fibers, removes metabolic by-products, enhances tissue metabolism, and stimulates nerve activity (Wiyoto, 2011).

The findings of this study demonstrate that massage manipulation therapy is an effective non-pharmacological intervention for reducing exercise-induced muscle pain in sprint athletes. The significant reduction in pain over four weeks of therapy improved athletes' physical comfort, supported recovery, and optimized performance. Therefore, the regular application of massage, particularly effleurage, shaking, and kneading, before and after training, is strongly recommended to maintain physical condition and minimize the risk of muscle injury.

Overall, this study provides evidence that combining effleurage, shaking, and kneading techniques not only reduces pain but also increases flexibility, offering a holistic approach to maintaining sprint athlete performance.

Analyzing the effects of manipulation massage therapy using a combination of effleurage, shaking, and hacking techniques on the Range of Motion (ROM) of the lower limbs before and after exercise

Theoretically, massage manipulation techniques such as effleurage, shaking, and hacking are effective in improving ROM through several physiological mechanisms. Effleurage and shaking enhance blood circulation and reduce muscle tension, while hacking helps loosen connective tissue and fascia that restrict joint movement. Improved circulation increases oxygen and nutrient supply to the tissues and accelerates muscle relaxation, thereby enhancing overall joint flexibility (Wijayanto, 2023; Wiyoto, 2011).

The findings of this study confirm a significant improvement in ROM over the four-week intervention period, demonstrating the effectiveness of these combined techniques for short-distance runners. ROM plays a crucial role in supporting athletic performance, particularly in sprinting, where lower-limb flexibility and mobility determine movement efficiency and speed. Thus, incorporating massage therapy into athletes' training programs can maximize movement capacity and reduce the risk of injury caused by limited joint mobility.

Overall, this study provides empirical evidence supporting massage manipulation therapy as a manual intervention that enhances ROM and contributes to improved physical readiness and the long-term quality of athletic training.

Analyzing the effects of massage manipulation therapy with a combination of effleurage, shaking, and hacking on lower-limb muscle pain before and after exercise

Theoretically, massage techniques such as effleurage, shaking, and hacking work through several mechanisms to reduce muscle pain. Effleurage increases blood flow and relaxes muscles; shaking stimulates the nervous system to reduce muscle tension; and hacking helps decrease muscle stiffness. This combination may reduce pain perception through the gate control theory (Melzack & Wall, 1965), which states that sensory stimulation can inhibit the transmission of pain

signals to the brain. Massage also helps reduce muscle tension and local inflammation, thereby lowering the perception of pain in athletes. According to Prentice (2024), excessive activity during intensive training often leads to muscle pain, which massage techniques can alleviate. For example, slow and rhythmic effleurage provides relaxation through sensory and motor nervous system stimulation (Wiyoto, 2011).

The results of this study confirm that routine massage therapy combining effleurage, shaking, and hacking is effective as a non-invasive intervention for reducing exercise-induced muscle pain. Pain reduction not only improves physical comfort but also accelerates recovery, allowing athletes to continue training under more optimal conditions. Therefore, this therapy is recommended as part of the training and recovery program for short-distance runners to maximize performance and prevent injuries associated with chronic muscle pain.

Overall, the findings demonstrate that the combination of effleurage, shaking, and hacking techniques significantly reduces muscle pain and supports the maintenance of athletes' overall physical condition.

Analyzing the influence of the control group on the Range of Motion (ROM) of the lower limbs before and after exercise

This study also examined the influence of the control group on the lower-limb range of motion (ROM) in short-distance runners from the SMAN 91 Jakarta athletics club over four weeks. ROM data were collected during the pre-test and post-tests in weeks 2, 3, and 4 to assess changes in joint mobility without additional therapeutic interventions.

The Kolmogorov-Smirnov and Shapiro-Wilk normality tests showed that the pre-test ROM data had a non-normal distribution ($p < 0.05$). In contrast, the post-test data for weeks 2–4 were normally distributed ($p > 0.05$). Therefore, the Friedman non-parametric test was used to analyze changes in ROM across the four measurements. The Friedman test results yielded a Chi-Square value of 66.27 with $df=3$ and $p=0.000$ ($p < 0.005$). However, although the mean rank increased slightly from 1.56 (pre-test) to 3.06 (week 4 post-test), this did not reflect a meaningful improvement in joint mobility for the control group.

The control group only received minimal intervention, namely one minute of effleurage, while relying primarily on regular training. The results indicate that exercise alone, without additional therapy, did not significantly improve lower-limb ROM.

ROM represents the ability of a joint to move within its full range and is influenced by factors such as muscle flexibility, connective tissue condition, injury, and inflammation. According to neuromuscular adaptation theory, meaningful improvements in ROM usually require additional stimulation, such as physical therapy, stretching, or massage manipulation, to enhance muscle and soft tissue flexibility. Exercise alone is often insufficient to produce significant short-term changes in joint mobility (Shrier & Gossal, 2000).

Based on these findings, it can be concluded that regular training without specific interventions, such as massage manipulation or therapeutic techniques, leads to stagnation in ROM improvement. Therefore, incorporating additional therapeutic interventions is essential to support rehabilitation, improve joint mobility, and reduce the risk of injury caused by limited flexibility.

Analyzing the effect of the control group on muscle pain in the lower limbs before and after exercise

The normality test results showed that all pain data in the control group were not normally distributed; therefore, the Friedman test was used for analysis. Although the results showed a significant statistical value (Chi-square=74.87; $p < 0.005$), the mean pain rank decreased from 3.48 (pre-test) to 1.91 (week 4 post-test). However, this decrease did not reflect a meaningful or consistent reduction in pain. The control group only received minimal treatment, namely one minute of effleurage without additional combination techniques. Thus, the effect of therapy on reducing lower-limb muscle pain was considered insignificant and suboptimal.

According to Prentice (2024), delayed onset muscle soreness (DOMS) from excessive training occurs due to microscopic tears in muscle fibers, particularly during eccentric or

isometric contractions. This damage is often accompanied by connective tissue disruption, local swelling, and delayed glycogen replenishment. Effective recovery requires therapeutic interventions that combine manipulation techniques, circulation stimulation, and muscle relaxation to reduce pain and accelerate recovery (Davis et al., 2020). While effleurage can increase blood flow, when applied briefly and without complementary techniques, its impact on pain reduction remains limited.

The findings of this study suggest that the control group, which received only brief effleurage without additional manipulation or combination techniques, did not experience a significant reduction in muscle pain. This emphasizes the importance of comprehensive therapeutic interventions with sufficient duration to reduce pain intensity effectively. Physiotherapists should consider integrating multiple massage techniques to optimize recovery after intensive exercise. Inadequate or overly minimal therapy may delay the healing process and increase the risk of long-term muscle dysfunction.

Analyzing the comparative effectiveness of manipulation massage therapy with combination techniques and a control group in improving lower-limb ROM

The ESH therapy group achieved the highest ROM, followed by the ESK therapy group, while the control group showed the lowest effectiveness. The results of the Kruskal-Wallis statistical test revealed a significance value of $p=0.000$ (<0.05), indicating a significant difference in effectiveness among the three groups. Specifically, ESH therapy (effleurage, shaking, and hacking) showed the highest mean rank, making it the most effective intervention for improving ROM in the lower limbs.

According to the theory of Range of Motion (ROM), reduced ROM can result from muscle tension, injury, or various medical conditions that restrict joint movement. Proper therapy is required to relieve muscle tightness and improve flexibility. Manipulation massage therapy has been shown to enhance ROM through mechanical stimulation, improvement of soft tissue function, increased blood circulation, and pain reduction. This aligns with previous findings indicating that massage supports circulation and helps restore normal muscle and joint function (Davis et al., 2020).

The use of combined massage techniques demonstrates superior results because it simultaneously addresses multiple factors influencing ROM. Davis et al. (2020) also reported that combining relaxation techniques with physical exercise can accelerate the recovery of physical function. Based on the present findings, ESH therapy showed the highest effectiveness, underscoring the importance of manual therapy in rehabilitation and functional recovery.

Therefore, it is recommended that physical therapy practitioners incorporate manipulation massage techniques, particularly ESH, into rehabilitation programs for individuals with lower-limb mobility issues. Further studies with larger sample sizes and different therapeutic variations are needed to provide additional insights into the relative effectiveness of these approaches. This is essential, as each patient has unique needs, and therapeutic responses may vary depending on physiological condition and individual adaptation.

In conclusion, manipulation massage therapy with the ESH technique (effleurage, shaking, and hacking) was significantly more effective in increasing ROM compared to the ESK technique (effleurage, shaking, and kneading) and the control group. These findings support the integration of manual therapy into athletic training and rehabilitation programs, particularly in schools, to enhance physical performance and maintain athlete health.

Analyzing the comparative effectiveness of manipulation massage therapy with combination techniques and a control group in reducing lower-limb muscle pain

In this analysis, the ESK therapy group (effleurage, shaking, and kneading) demonstrated the highest effectiveness in reducing lower-limb muscle pain compared to the ESH therapy group (effleurage, shaking, and hacking) and the control group. The statistical test results indicated a significant difference in therapy effectiveness among the three groups ($p < 0.05$), confirming that ESK therapy was superior in alleviating muscle pain.

Theoretically, muscle pain often arises from tension, inflammation, and fatigue. Appropriate therapeutic interventions can help relieve tension and accelerate recovery (Davis et al., 2020). According to the muscle recovery theory, techniques that stimulate circulation, such as manipulation and massage, enhance the removal of metabolic waste and increase oxygen delivery to muscle tissue, both of which are critical for the healing process (Sari, 2018). Research also shows that combination techniques, such as those in the ESK group, are more effective because they address pain from multiple perspectives, through mechanical stimulation, improved flexibility, and enhanced muscle strength (Rahmawati et al., 2021).

The findings, which identify ESK as the most effective approach, highlight the importance of combination techniques in physical therapy. By integrating manipulation and exercise-based methods, this therapy not only reduces pain more effectively but also supports the prevention of recurring pain. Therefore, physiotherapists are encouraged to incorporate ESK massage techniques into rehabilitation programs for athletes experiencing lower-limb muscle pain.

CONCLUSION

This study indicates that manipulation massage therapy with combination techniques has a significant effect in reducing Delayed Onset Muscle Soreness (DOMS) and improving Range of Motion (ROM) in student sprint athletes of the SMAN 91 Jakarta Athletics Club. The combination of effleurage, shaking, and kneading (ESK) appeared to be more effective in reducing muscle pain levels, while the combination of effleurage, shaking, and hacking (ESH) showed better results in improving lower-limb ROM. The results of statistical analysis using the Friedman and Kruskal-Wallis tests suggest that both therapy techniques were more effective than the control group in reducing pain and enhancing motor function. These findings support the potential of manipulation massage therapy as a preventive and rehabilitative intervention in student-athlete development programs within school settings. Therefore, it is recommended that such therapy be considered for integration into athletes' training routines to support performance and help reduce the risk of muscle injuries associated with intensive training.

REFERENCES

- Cheung, K., Hume, P. A., & Maxwell, L. (2003). *Delayed onset muscle soreness: treatment strategies and performance factors*. In *Sports Medicine* (Vol. 33, Issue 2). <https://doi.org/10.2165/00007256-200333020-00005>
- Connolly, D. A. J., Sayers, S. P., & McHugh, M. P. (2003). Treatment and prevention of delayed onset muscle soreness. *Journal of Strength and Conditioning Research*, 17 (1). [https://doi.org/10.1519/1533-4287\(2003\)017%3C0197:TAPODO%3E2.0.CO;2](https://doi.org/10.1519/1533-4287(2003)017%3C0197:TAPODO%3E2.0.CO;2)
- Davis, H. L., Alabed, S., & Chico, T. J. A. (2020). Effect of sports massage on performance and recovery: a systematic review and meta-analysis. *BMJ Open Sport & Exercise Medicine*, 6(1). <https://doi.org/10.1136/bmjsem-2019-000614>
- Fitrian, Z. A. (2023). Pengaruh treatment sport massage terhadap pencegahan timbulnya delayed onset muscle soreness pada pemain futsal sman 1 banjarasin. [Thesis]. Yogyakarta: Fakultas Ilmu Keolahragaan dan Kesehatan, Univesitas Negeri Yogyakarta.
- Kerr, Z. Y., Lynall, R. C., Roos, K. G., Dalton, S. L., Djoko, A., & Dompier, T. P. (2017). Descriptive epidemiology of non-time-loss injuries in collegiate and high school student-athletes. *Journal of athletic training*, 52(5), 446-456. <https://doi.org/10.4085/1062-6050-52.2.15>
- Mahesvi, H., Sukarmin, Y., Suhartini, B., Bartik, P., Hansdorfer-Korzon, R., & Adil, H. M. (2024). How does ali satia graha and thai massage method compare? Study on pain and range of motion of chronic ankle injury. *Tanjungpura Journal of Coaching Research*, 2(3), 124-130. <https://doi.org/10.26418/tajor.v2i3.65878>
- McEwen, J. A., Owens, J. G., & Jeyasurya, J. (2019). Why is it crucial to use personalized occlusion pressures in blood flow restriction (bfr) rehabilitation. *Journal of Medical and Biological Engineering*, 39(2). <https://doi.org/10.1007/s40846-018-0397-7>

- Melzack, R., & Wall, P. D. (1965). Pain mechanisms: a new theory: a gate control system modulates sensory input from the skin before it evokes pain perception and response. *Science*, 150(3699), pp. 971–979. <https://doi.org/10.1126/science.150.3699.971>
- Peake, J. M., Neubauer, O., Gatta, P. A. D., & Nosaka, K. (2017). Muscle damage and inflammation during recovery from exercise. *Journal of Applied Physiology*, 12(3). <https://doi.org/10.1152/jappphysiol.00971.2016>
- Pemerintah Republik Indonesia. (2003). *Undang-Undang Nomor 20 Tahun 2003 tentang Sistem Pendidikan Nasional*. Jakarta.
- Pemerintah Republik Indonesia. (2005). *Undang-Undang Nomor 3 Tahun 2005 tentang Sistem Keolahragaan Nasional*. Jakarta.
- Prentice, W. (2024). *Rehabilitation techniques for sports medicine and athletic training*. Taylor & Francis. <https://doi.org/10.4324/9781003526308>
- Priyoadi, B., Sutapa, P., & Graha, A. S. (2019). Sports Massage to Improve the Immunoglobulin A (Iga) and the Hormon Beta Endorphin. *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* (Vol. 1, pp. 704-709). <https://doi.org/10.5220/0009801807040709>
- Proske, U., & Morgan, D. L. (2001). Muscle damage from eccentric exercise: mechanism, mechanical signs, adaptation, and clinical applications. *Journal of Physiology*, 537 (2). <https://doi.org/10.1111/j.1469-7793.2001.00333.x>
- Rahmawati, P. L., Dwiningsih, S. R., & Herawati, L. (2021). A combination of effleurage and kneading massage can reduce the intensity of dysmenorrhea. *Indonesian Midwifery and Health Sciences Journal*, 4(1). <https://doi.org/10.20473/imhsj.v4i1.2020.51-59>
- Sari, S. (2018). Mengatasi doms setelah olahraga. *Motion: Jurnal Riset Physical Education*, 7(1). <https://doi.org/10.33558/motion.v7i1.500>
- Shrier, I., & Gossal, K. (2000). Myths and truths of stretching. *The Physician and Sportsmedicine*, 28(8), pp. 57-63. <https://doi.org/10.3810/psm.2000.08.1159>
- Weerapong, P., Hume, P. A., & Kolt, G. S. (2005). The mechanisms of massage and its effects on performance, muscle recovery, and injury prevention. *Sports Medicine*, 35(3). <https://doi.org/10.2165/00007256-200535030-00004>
- Wijayanto, A. (2023). *Sport massage: pijat kebugaran olahraga*. Tulung Agung: Akademia Pustaka. <https://doi.org/10.31219/osf.io/mwbfx>
- Wiyoto, B. T. (2011). *Remedial massage panduan pijat penyembuhan bagi fisioterapis praktisi, dan instruktur*. Yogyakarta: Nuha Medika.
- World Health Organization. (2019). *Global action plan on physical activity 2018-2030: more active people for a healthier world*. World Health Organization.