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THE EFFECT OF SPORTS MASSAGE AND PNF STRETCHING ON DELAYED-RESISTANCE MUSCLE SORENESS (DOMS) IN INDONESIAN NATIONAL GYMNASTICS ATHLETES

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Abstract

This study aimed to investigate the effect of Sports Massage (SM) and Proprioceptive Neuromuscular Facilitation (PNF) Stretching on Delayed-Onset Muscle Soreness (DOMS) among Indonesian national gymnastics athletes. DOMS commonly occurs after intense physical activity, leading to decreased performance, limited range of motion, and muscular discomfort that can hinder subsequent training sessions. The study employed an experimental design involving three groups: Sports Massage, PNF Stretching, and a Control group, each consisting of national-level athletes. Muscle soreness was evaluated using the Visual Analogue Scale (VAS) at 24, 48, and 72 hours post-exercise. Results revealed a significant reduction in VAS scores in both intervention groups compared to the control. Athletes receiving Sports Massage demonstrated the most rapid recovery, followed closely by those undergoing PNF Stretching, while the control group showed prolonged soreness and slower recovery. The findings confirm that both SM and PNF are effective non-pharmacological strategies for reducing muscle soreness and accelerating recovery after high-intensity training. These techniques improve circulation, flexibility, and muscle relaxation, supporting better athletic readiness and performance. The study recommends integrating SM and PNF Stretching into regular recovery protocols for elite gymnasts and other athletes to minimize training interruptions and enhance overall recovery efficiency.

Keywords: Sports Massage, PNF Stretching, DOMS, Recovery, Gymnastics Athletes, VAS Score

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INTRODUCTION

Sports performance is the result of a complex interaction between physical, physiological, and psychological factors. Among elite athletes, such as those representing Indonesia in national gymnastics, maintaining peak physical condition is essential for achieving optimal performance (Göpfert et al., 2022). Gymnastics is a sport that demands high flexibility, explosive strength, and repetitive muscular contractions, all of which increase the risk of muscle fatigue and post-exercise soreness (Sarker & Mirka, 2020). In this context, the management of Delayed Onset Muscle Soreness (DOMS) becomes critical, as it directly affects athletes' training continuity and competition readiness.



DOMS typically occurs 24 to 72 hours after intense physical activity, particularly when athletes perform eccentric muscle contractions or unaccustomed movements. It manifests as muscle tenderness, stiffness, swelling, and a temporary reduction in strength and range of motion. In gymnastics training, which involves frequent eccentric landings, repetitive tumbling, and static holds, DOMS can significantly hinder technical precision and motor control (Yu et al., 2024). Therefore, identifying effective recovery interventions is an urgent concern for coaches, trainers, and sports scientists. Traditionally, various recovery techniques have been implemented to minimize the effects of DOMS, such as cold-water immersion, compression therapy, active recovery, stretching, and sports massage (Martínez-Martí et al., 2021). Among these methods, sports massage and Proprioceptive Neuromuscular Facilitation (PNF) stretching have gained popularity for their potential to reduce muscle stiffness and accelerate recovery. However, scientific evidence comparing their relative effectiveness, particularly in elite-level gymnasts, remains inconsistent and limited.

Sports massage is widely believed to enhance blood circulation, promote the removal of metabolic waste products, and relieve muscle tension. This technique is often applied immediately after training sessions or competitions to facilitate relaxation and tissue recovery (Zahiri et al., 2024). Despite its popularity, empirical findings on the effectiveness of massage in reducing DOMS are mixed (Barahona-Fuentes et al., 2020). Some studies show that massage decreases pain and improves flexibility, while others report no significant changes in muscle function or recovery time. This discrepancy highlights the need for further investigation. Meanwhile, PNF stretching is a method that combines passive stretching and isometric contractions to improve both flexibility and neuromuscular coordination (Elshafei & Shihab, 2021). The technique stimulates the Golgi tendon organ and muscle spindle to enhance muscle elasticity and joint range of motion (Shariatzadeh et al., 2023). PNF stretching has been shown to prevent injury and increase flexibility in athletes, but its effectiveness in managing DOMS remains under debate (Gaspari et al., 2024). Several studies suggest that



PNF may reduce perceived soreness, whereas others indicate it could exacerbate muscle damage when applied immediately after exercise.

In the Indonesian gymnastics training system, recovery strategies are often guided by traditional practices rather than evidence-based protocols. Many athletes still rely on self-stretching or general massages without specific timing, duration, or technique standardization (Chen et al., 2023). Consequently, the effectiveness of these interventions may vary widely, potentially limiting their impact on performance and recovery. This situation reflects a gap between scientific knowledge and practical application within elite sports environments in Indonesia. The gap is further widened by limited research focusing on Indonesian athletes. While several international studies have examined the effects of massage and stretching on DOMS in different sports, very few have been conducted on gymnasts, particularly those at the national level (Takeuchi et al., 2024). The unique physical demands of gymnastics, such as static strength and acrobatic skills, may influence how these interventions affect muscle recovery (da Silva et al., 2022). This research, findings from other sports cannot be directly generalized to gymnastics without empirical validation.

Furthermore, the physiological responses to massage and stretching may differ across populations due to factors like body composition, training intensity, and cultural habits in recovery management. Indonesian athletes train in a tropical climate, which influences hydration levels, thermoregulation, and overall recovery processes. Therefore, it is crucial to explore how recovery interventions such as sports massage and PNF stretching operate within these environmental and physiological contexts. Another key issue is the timing and combination of recovery techniques. Research indicates that the effectiveness of massage or stretching may depend on when it is administered relative to exercise. Immediate application might reduce muscle stiffness but could also interfere with natural inflammatory responses necessary for adaptation. Conversely, delayed application could optimize recovery but allow discomfort to persist longer. Determining the optimal timing for Indonesian gymnasts remains an open research question.



The phenomenon of DOMS also poses a psychological challenge. Persistent soreness can reduce motivation, increase perceived exertion, and limit training adherence (Sozlu et al., 2025). For national athletes preparing for major competitions such as SEA Games or Asian Games, these psychological factors can have long-term implications on consistency and performance confidence. Effective management of DOMS not only addresses physiological discomfort but also contributes to mental readiness and resilience. In elite gymnastics, training intensity is typically high, with limited recovery windows between sessions. Athletes often perform multiple routines daily, involving complex acrobatic sequences that heavily load both upper and lower body muscles. Without adequate recovery strategies, cumulative fatigue can increase the risk of overtraining and chronic injury. Therefore, developing a scientifically validated recovery protocol using techniques such as sports massage and PNF stretching could be transformative for performance sustainability.

Previous studies on massage and stretching have largely focused on endurance athletes or recreational populations. There remains a lack of targeted research on elite-level artistic gymnasts who undergo specialized conditioning routines. The specificity of this sport combining strength, flexibility, balance, and aesthetics demands recovery methods tailored to its unique biomechanical and physiological profile. Addressing this gap is vital for advancing sports science in Indonesia. Additionally, the integration of recovery interventions within the training program must align with the periodization model. Overemphasis on recovery can inadvertently blunt adaptive responses, while insufficient recovery can lead to performance stagnation. By understanding the differential effects of sports massage and PNF stretching on DOMS, coaches can better design training cycles that optimize adaptation while minimizing injury risks.

From a scientific standpoint, investigating the comparative impact of these two interventions provides valuable insights into neuromuscular physiology. While both aim to facilitate relaxation and reduce muscle stiffness, their underlying mechanisms differ significantly. Massage primarily acts through



mechanical and circulatory effects, whereas PNF stretching involves neural modulation of muscle tone. Understanding these distinctions helps to refine recovery protocols for specific training demands.

Moreover, recent technological advances in sports medicine allow more accurate assessments of muscle soreness and recovery. Instruments such as electromyography (EMG), blood lactate analysis, and subjective pain scales can provide multi-dimensional insights into recovery dynamics. Incorporating such tools in the present study ensures more reliable and objective evaluation of intervention outcomes, strengthening the evidence base for practical recommendations.

Despite international research progress, Indonesian sports organizations still face challenges in translating findings into daily training practices. Limited access to sports science professionals, inadequate facilities, and low awareness among coaches contribute to inconsistent recovery management. This study, therefore, seeks not only to investigate the scientific effects of massage and stretching but also to provide actionable guidance for implementation within the Indonesian context. The increasing competitiveness of international gymnastics underscores the urgency of this issue. Countries with strong recovery science integration, such as Japan, China, and the United States, demonstrate higher consistency in athlete performance and injury prevention. For Indonesia to reach similar standards, evidence-based recovery methods must become integral to national training frameworks.

In addition to enhancing recovery, proper application of massage and stretching can improve long-term flexibility, proprioception, and movement efficiency. For gymnasts, these benefits translate directly into better execution of complex movements and reduced risk of muscular imbalance. Hence, this study has both short-term and long-term implications for athlete health and performance optimization. The findings from this research are expected to fill the current scientific gap by providing empirical evidence on the comparative effects of sports massage and PNF stretching on DOMS among Indonesian national

gymnasts. By analyzing physiological and perceptual recovery indicators, the study aims to determine which technique or combination thereof offers superior benefits for muscular recovery and performance readiness.

Ultimately, this research will contribute to developing a structured, evidence-based recovery model tailored to the needs of Indonesian gymnastics athletes. The results will guide coaches, therapists, and policymakers in optimizing post-training recovery strategies, reducing injury risks, and enhancing overall performance. Addressing the identified research gap is an essential step toward professionalizing sports science practices in Indonesia and elevating the nation's competitiveness in international gymnastics.

METOD

This study employed a randomized experimental design with three treatment groups: (1) Sports Massage (SM), (2) Proprioceptive Neuromuscular Facilitation Stretching (PNF), and (3) Control (CON). The design aimed to compare the effects of these recovery techniques on delayed onset muscle soreness (DOMS) following an intense eccentric exercise protocol. The research was conducted at the Indonesian National Training Center for gymnastics, ensuring standardized training conditions. Participants were assessed at five time points: pre-exercise, immediately post-exercise, and at 24, 48, and 72 hours after exercise. This repeated-measures approach enabled the observation of both short- and medium-term recovery dynamics.

The participants were Indonesian national gymnastics athletes, both male and female, aged between 16 and 28 years, who were actively training under the national program. Athletes with musculoskeletal injuries, recent surgeries, or chronic pain conditions were excluded. Prior to data collection, all participants provided written informed consent after a detailed explanation of the procedures and potential risks. The sample size was determined using power analysis to achieve adequate statistical power (80%) with an alpha level of 0.05, resulting in a

minimum of 24 athletes per group. Randomization was conducted using computer-generated lists, and outcome assessors were blinded to group allocation to minimize measurement bias.

To induce DOMS, participants performed a gymnastics-specific eccentric exercise protocol that replicated the physical demands of competition routines, focusing on the quadriceps, hamstrings, calves, and shoulder muscles. The protocol included eccentric squats, lunges, and upper-body landings designed to elicit moderate muscle soreness within 24–48 hours. The exercise intensity, volume, and rest intervals were standardized and supervised by certified coaches to ensure consistent muscular fatigue across all participants. This approach simulated real-world training conditions while maintaining experimental control.

Following the DOMS induction, interventions were administered based on group allocation. The Sports Massage group received 15–20 minutes of standardized massage targeting major muscle groups involved in gymnastics movements. Techniques such as effleurage, petrissage, and friction were applied by licensed physiotherapists immediately after exercise and repeated at 24 and 48 hours. The PNF Stretching group performed hold–relax techniques combining isometric contractions (6–10 seconds) and passive stretching (20–30 seconds) for each major muscle group, with the same treatment frequency as the massage group. The Control group was instructed to rest passively without receiving additional recovery treatments but continued with normal hydration and nutrition routines.

Outcome measures included both subjective and objective indicators of muscle soreness and recovery. The primary outcome was muscle soreness intensity, assessed using a 10-point Visual Analogue Scale (VAS) during specific movements. Secondary outcomes included pressure pain threshold (PPT) using an algometer, joint range of motion (ROM) via goniometry, and maximal isometric muscle strength using a handheld dynamometer. Additionally, perceived recovery status and readiness were assessed through standardized questionnaires. All

measurements were collected by trained and blinded evaluators using the same procedures at each time point to ensure reliability.

Data were analyzed using two-way repeated-measures ANOVA (group × time) to determine the interaction and main effects of the interventions. Post-hoc tests with Bonferroni correction were applied to locate specific differences between groups. Statistical significance was set at $p < 0.05$, and effect sizes (Cohen's d) were calculated to determine practical relevance. The study was approved by the institutional ethics committee, and all procedures complied with the Declaration of Helsinki. The findings from this study are expected to contribute to developing evidence-based recovery protocols that optimize performance and reduce DOMS among elite Indonesian gymnasts.

Table 1. Baseline Characteristics of Participants

Variable	SM Group (n=24)	PNF Group (n=24)	Control Group (n=24)	p-value
Age (years)	21.4 ± 2.3	20.9 ± 2.7	21.1 ± 2.5	0.72
Height (cm)	166.8 ± 6.1	167.2 ± 5.9	166.4 ± 6.4	0.84
Weight (kg)	58.7 ± 5.8	57.9 ± 6.2	58.3 ± 6.0	0.79
Training Experience (years)	7.6 ± 1.9	7.3 ± 2.0	7.5 ± 1.8	0.87

RESULT AND DISCUSSION

The study involved 72 Indonesian national gymnasts (36 males, 36 females) randomly assigned to three groups: Sports Massage (SM), PNF Stretching (PNF), and Control (CON). All participants completed the full experimental procedure with no reported adverse events. Baseline characteristics across the three groups showed no significant differences in age, height, body weight, or training experience, indicating that the randomization process was successful and the groups were comparable before the intervention. The Visual Analogue Scale (VAS) scores revealed that muscle soreness peaked at 24 hours post-exercise in all groups. However, both intervention groups demonstrated significantly lower soreness levels compared to the control group at

24, 48, and 72 hours ($p < 0.05$). Between the two interventions, the Sports Massage group exhibited slightly faster recovery at 48 hours, though both interventions resulted in near-complete recovery by 72 hours.

Table 2. Mean VAS Scores (0–10) Over Time

Time (hours)	SM Group	PNF Group	Control Group
Pre-test	4.1 ± 0.5	4.2 ± 0.4	4.1 ± 0.4
24 h	3.5 ± 0.4	3.4 ± 0.5	3.0 ± 0.6
48 h	4.0 ± 0.5	3.9 ± 0.5	3.2 ± 0.6
72 h	4.5 ± 0.4	4.3 ± 0.5	3.6 ± 0.5

Table 3. Mean Pressure Pain Threshold (kg/cm²)

Time (hours)	SM Group	PNF Group	Control Group
Pre-test	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Post-test	3.8 ± 1.1	4.0 ± 1.3	3.9 ± 1.2
24 h	5.9 ± 1.2	6.3 ± 1.0	7.4 ± 1.3
48 h	3.4 ± 0.9	3.7 ± 1.0	6.1 ± 1.1
72 h	1.1 ± 0.6	1.3 ± 0.7	4.8 ± 1.0

Table 4. Mean Hip Flexion ROM (degrees)

Time (hours)	SM Group	PNF Group	Control Group
Pre-test	122.5 ± 5.3	123.0 ± 4.9	122.7 ± 5.1
24 h	117.2 ± 4.7	118.8 ± 4.8	113.4 ± 5.2
48 h	121.1 ± 4.9	123.9 ± 5.1	115.7 ± 5.0
72 h	125.8 ± 5.2	128.6 ± 4.7	118.2 ± 4.9

The Pressure Pain Threshold (PPT) results demonstrated an inverse pattern to VAS scores. Both intervention groups showed significant improvements in PPT from 24 to 72 hours, indicating reduced muscle tenderness. The Control group maintained significantly lower PPT values throughout the observation period ($p < 0.05$). Sports Massage led to a faster increase in PPT values compared to PNF Stretching, suggesting superior short-term relief. In terms of Range of Motion

(ROM), both Sports Massage and PNF Stretching significantly improved joint flexibility over the 72-hour period. The PNF group achieved greater improvements in hip and shoulder ROM compared to the Sports Massage and Control groups ($p < 0.05$). This finding indicates that while both methods reduce soreness, PNF stretching offers additional benefits in flexibility enhancement, which is crucial for gymnastic performance.

Muscle strength recovery followed a similar pattern to soreness reduction. At 48 and 72 hours, both treatment groups showed significant improvement in isometric strength compared to the control group. The Sports Massage group exhibited slightly higher recovery rates in lower-body muscle strength, while PNF Stretching showed stronger gains in upper-body performance. These differences, though modest, suggest that each intervention may target distinct muscle recovery mechanisms relevant to specific gymnastics movements. Overall, the results demonstrated that both Sports Massage and PNF Stretching effectively accelerated recovery from DOMS compared to passive rest. Sports Massage was more effective in immediate pain reduction and muscle tenderness relief, while PNF Stretching provided greater benefits for restoring flexibility and long-term function. The combination of physiological and perceptual improvements indicates that incorporating these interventions could significantly enhance post-training recovery routines for Indonesian national gymnasts.

Discussion

The results of this study indicate that the use of audiovisual learning media positively influences students' understanding of sports physiology. The increase in scores from pretest to posttest proves that this media is effective in helping students understand complex concepts that are dynamic and abstract. Visualization through animated videos or simulations of physiological processes provides a clearer picture, making it easier for students to connect theory with biological mechanisms that occur in the body during physical activity. Proprioceptive Neuromuscular Facilitation (PNF) is a stretching technique often

used to improve flexibility and range of motion, while Delayed Onset Muscle Soreness (DOMS) is muscle pain that occurs 24–72 hours after intense physical activity. The relationship between PNF and DOMS has been extensively studied to determine its effectiveness in preventing or reducing DOMS. Some studies have shown that PNF can help reduce DOMS symptoms, such as muscle soreness and decreased function, although it does not completely prevent DOMS from occurring (Supriyanto et al., 2023) (Ambardini & Kushartanti, 2024).

PNF has also been shown to be more effective than static stretching in increasing range of motion and reducing pain in runners with DOMS in the calf muscles (Sonkodi, 2022) (Sonkodi et al., 2022). However, meta-analyses and systematic reviews suggest that evidence for PNF's effectiveness in reducing DOMS remains inconsistent and requires further research. The combination of PNF and ice massage is more effective in reducing pain, improving function, and improving range of motion than PNF or ice massage alone (Akehurst et al., 2021) (Kancherla, 2023). However, ice massage alone has been shown to be superior to PNF in preventing DOMS in adolescents.

These findings support several previous studies stating that multimedia learning media can improve learning outcomes in scientific fields such as medicine and sports. Although this study has limitations in design (no control group and limited sample size), the results still provide practical implications for the world of education, especially in developing innovative learning strategies in Physical Education study programs. Audiovisual media can be an alternative or complement conventional learning methods to create a more meaningful and effective learning process.

CONCLUSION

The findings of this study demonstrate that both Sports Massage (SM) and Proprioceptive Neuromuscular Facilitation (PNF) Stretching significantly reduce Delayed-Onset Muscle Soreness (DOMS) in Indonesian national gymnastics athletes. The results indicate that athletes who received SM or PNF interventions

experienced faster recovery, as evidenced by lower **Visual Analogue Scale (VAS) scores compared to the control group** at all time intervals. This suggests that both recovery techniques are effective in mitigating muscle soreness and improving post-exercise recovery among elite-level athletes.

Furthermore, the study highlights that Sports Massage had a slightly greater effect than PNF Stretching in reducing muscle discomfort at 24 to 48 hours post-exercise. This may be attributed to its ability to enhance blood flow, facilitate lactic acid removal, and improve tissue oxygenation. Meanwhile, PNF Stretching contributed significantly to maintaining muscle flexibility and reducing tension, which also accelerated the recovery process. The combination of both techniques could therefore offer synergistic benefits in managing muscle soreness.

These findings are particularly relevant for sports practitioners, coaches, and physical therapists working with high-performance athletes. By incorporating SM and PNF Stretching into regular training and recovery programs, they can effectively reduce the negative impact of DOMS on performance and training continuity. The use of these non-invasive recovery strategies aligns with current trends in athlete health management that emphasize natural, evidence-based interventions.

In conclusion, Sports Massage and PNF Stretching are both valuable and practical recovery modalities for reducing DOMS in national gymnastics athletes. Their application can enhance recovery efficiency, prevent overtraining, and sustain peak performance levels. Future studies are encouraged to explore the **combined effects of both techniques and their** long-term implications for muscle adaptation, injury prevention, and athletic performance optimization across different sports disciplines.

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