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**EXTENDED  
ABSTRACT**

# Effect of Foam Rolling (FR) and Proprioceptive Neuromuscular Facilitation (PNF) Stretching on Muscle Soreness Among U-17 Negeri Sembilan Football Club (NSFC) Female Soccer Players

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## I. INTRODUCTION

Delayed Onset Muscle Soreness (DOMS) is a common affliction among athletes, particularly those engaged in high-intensity sports such as soccer [1]. The efficacy of various recovery techniques, including Foam Rolling (FR) and proprioceptive neuromuscular facilitation (PNF) stretching, in mitigating muscle soreness is well-established within the sports science community [2]. However, there is a notable gap in research comparing these techniques, especially in female soccer players. The majority of existing studies focus on male athletes, leaving uncertainty regarding the applicability of these methods for females, whose physiological responses may differ due to hormonal fluctuations, muscle composition, and training adaptations [3]. Accordingly, this study aims to investigate the effects of Foam Rolling (FR) and PNF stretching on muscle soreness among U-17 female soccer players from Negeri Sembilan Football Club (NSFC).

## II. METHODS

### A. Subjects

The participants in this study were female football players from the Negeri Sembilan Football Club (NSFC) U17 team. A total of twenty players were randomly assigned to one of two intervention groups: the Foam Roller (FR) group ( $n = 10$ ) or the Proprioceptive Neuromuscular Facilitation (PNF) stretching group ( $n = 10$ ). Before participation, informed consent was obtained for each procedure to ensure that all participants voluntarily agreed to take part in the study. The inclusion criteria for participants were as follows: (1) Female football players under the age of 17 from Negeri Sembilan Football Club (NSFC), (2) Actively engaged in both training and competitive activities with the Negeri Sembilan Football Club, (3) Good physical health without any current injuries, and (4) Have no history of metabolic, cardiovascular, or pulmonary disorders.

### B. Instrumentation

#### Range of Motion

To assess active range of motion (AROM), the researcher employed a goniometer, a standard instrument for measuring joint angles. Participants were instructed to flex their knees to the maximum extent possible while maintaining a neutral position at the hips and ensuring full contact with the testing

surface. AROM measurements were recorded at four intervals: before the match (baseline), and at 24, 48, and 72 hours following the intervention. The knee joint was selected for assessment due to its susceptibility to exercise-induced muscle soreness. All data were systematically recorded using individualized data collection forms. According to normative values, knee flexion typically ranges from 0 to 135–150 degrees [4].

#### Pain Scale

The participants were instructed to evaluate their pain intensity both at rest and during movement, using a scale ranging from 0 to 10. Pain perception was measured with the Visual Analogue Scale (VAS), a 10-cm horizontal line where 0 represents "no pain," 1 to 3 indicates "mild pain," 4 to 6 corresponds to "moderate to severe pain," 7 to 9 denotes "very severe pain," and 9 to 10 reflects the "worst pain imaginable." The VAS was administered at several time points: before the match, immediately post-match, and at 24, 48, and 72 hours after the treatment. The VAS scores were employed to evaluate the impact of the interventions on pain intensity among the female football players [5].

### C. Procedure

Baseline measurements of pain intensity and knee range of motion (ROM) were taken before the match. Participants then played an 80-minute football match to induce delayed onset muscle soreness (DOMS) [6]. Participants were randomly assigned to either a Foam Rolling (FR) group or a PNF stretching group. The FR group performed five foam rolling exercises targeting the calf muscles, quadriceps, hamstrings, iliotibial band, and gluteal muscles. Each muscle group was rolled slowly for 30 seconds in a guided 15–20-minute session [7]. In the PNF group, participants held a stretch for 10 seconds, then performed a 6-second contraction against the researcher's resistance, followed by a passive stretch until a stretch sensation was reported [8]. Pain and ROM were measured again at 24, 48, and 72 hours post-treatment to compare the effects of the two recovery methods.

#### D. Statistical Analysis

A quasi-experimental design was employed to evaluate the effects of Foam Rolling (FR) and proprioceptive neuromuscular facilitation (PNF) stretching on markers of exercise-induced muscle soreness. Before analysis, the dataset was reviewed for missing or inconsistent values, and basic data cleaning procedures were performed. Statistical analyses were conducted using JAMOVI software (version 2.6.22). Repeated measures ANOVA was used to compare mean pain scores and ROM between the FR and PNF groups, as well as to assess changes in pain scores across multiple time points.

### III. RESULTS

The results indicated a significant effect of both the Foam Rolling (FR) and PNF stretching interventions on the measured outcomes, pain scale (PS), and active range of motion (AROM) in knee flexion across all four time points. As presented in Table 1, the main effects for both interventions on PS and AROM were statistically significant, with a p-value of 0.001. These findings suggest that both recovery strategies led to significant changes in pain intensity and knee range of motion over time.

TABLE I  
EFFECT TOWARDS ROM

Effect	<i>p</i>	Eta Square
PS	<0.001	0.846
AROMR	<0.001	0.368
AROML	<0.001	0.394

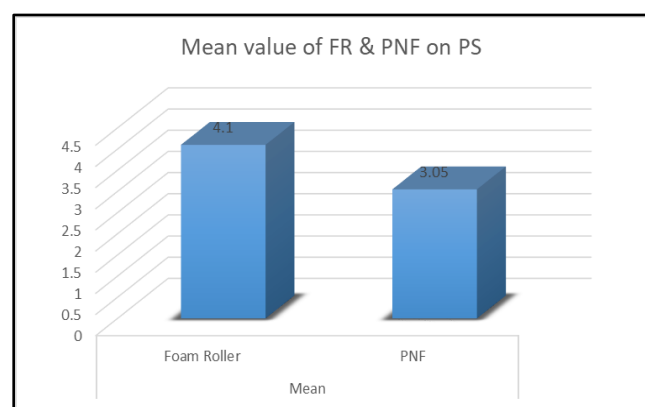


Fig.1 Mean value of FR and PNF on Pain Scale (PS).

Figure 1 illustrates a consistent decrease in pain scale (PS) scores across the four time points for both intervention groups. Based on the mean (*M*) values, the PNF stretching group reported a lower overall PS (*M* = 3.05) compared to the Foam Roller (FR) group (*M* = 4.10), indicating a greater reduction in perceived pain for the PNF group. Figure 2 displays changes in active range of motion (AROM) over time, showing an

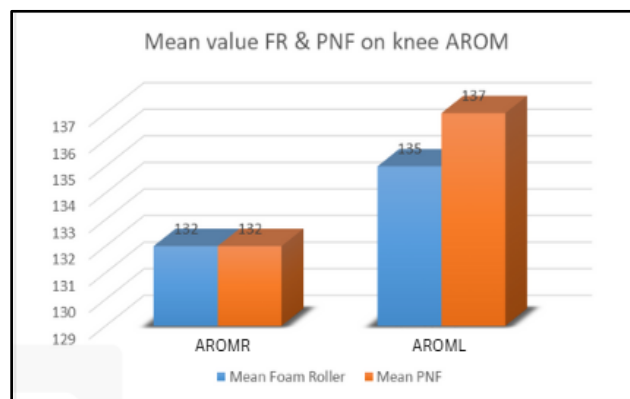


Fig.2 Mean value of FR and PNF on AROMR and AROML

overall increase in both right (AROMR) and left (AROML) knee flexion. The PNF group demonstrated slightly higher mean values for AROMR and AROML (132° and 137°, respectively), compared to the FR group (132° and 135°, respectively). Although both interventions resulted in improved AROM, statistical analysis revealed a significant difference between groups only for the pain scale, with no significant group differences for AROM outcomes.

### IV. DISCUSSIONS

The present study investigated the effects of Foam Rolling (FR) and Proprioceptive Neuromuscular Facilitation (PNF) stretching on markers of exercise-induced muscle soreness, specifically pain intensity and knee range of motion (ROM) in U17 female football players from the Negeri Sembilan Football Club (NSFC). Both interventions are commonly used to facilitate post-exercise recovery, and the findings of this study support their effectiveness in reducing muscle soreness following match play.

The results revealed a significant reduction in pain scale (PS) across both intervention groups, with PNF stretching demonstrating a greater effect. This suggests that PNF stretching may be more effective in relieving symptoms of delayed onset muscle soreness (DOMS). This outcome aligns with previous findings indicating that PNF techniques can modulate nociceptive input, thereby decreasing pain sensitivity through neuromuscular mechanisms. Specifically, the activation of Golgi tendon organs during PNF stretching is believed to play a key role in promoting muscle relaxation and reducing tension [9]. These physiological responses likely contributed to the greater pain relief observed in the PNF group.

With respect to active range of motion (AROM) in knee flexion, both the FR and PNF interventions led to improvements over time. While the PNF group showed slightly higher mean values for AROM in both the right and left knees, the difference between the groups was not statistically significant. These findings suggest that both interventions are comparably effective in restoring knee mobility post-exercise. This is supported by prior research demonstrating that PNF stretching, particularly using hold-relax and contract-relax techniques can enhance both passive

and active ROM through neuromuscular adaptations [10]. Similarly, other studies have shown that foam rolling improves muscle flexibility and AROM, particularly in the hamstrings, over a period of consistent application [11].

In addition to reducing pain and improving flexibility, both interventions may contribute to reducing the risk of muscle injuries associated with high-intensity physical activity. The treatments appear to alleviate DOMS symptoms, enhance functional recovery, and potentially improve muscular performance. These outcomes highlight the practical relevance of incorporating FR and PNF stretching into post-match recovery routines for adolescent athletes.

Overall, the findings suggest that while both FR and PNF are effective recovery strategies, PNF stretching may offer superior benefits in reducing pain. However, both methods appear equally beneficial in improving the active knee range of motion. Coaches and sports practitioners may consider integrating either technique based on specific recovery goals and individual athlete response.

#### V. CONCLUSIONS

This study concluded that Proprioceptive Neuromuscular Facilitation (PNF) stretching was more effective than Foam Rolling (FR) in reducing post-match muscle soreness, as evidenced by significantly lower pain scale (PS) scores among U17 female football players from the Negeri Sembilan Football Club (NSFC). Both interventions significantly improved pain and knee range of motion (ROM) over time, indicating their general effectiveness as recovery strategies.

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