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**EXTENDED
ABSTRACT**

Effect of Foam Rolling and Proprioceptive Neuromuscular Facilitation (PNF) Stretching on Agility and Muscular Performance Among U-17 Negeri Sembilan Football Club (NSFC) Female Players

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I. INTRODUCTION

Agility is widely believed to be a crucial physical component necessary for successful performance in many sports, particularly football, where quick changes in direction and rapid responses are essential [1]. In addition, muscular endurance enables players to sustain repeated high-intensity efforts throughout a full match, contributing significantly to overall performance [2]. Among the commonly used methods to enhance these components, foam rolling and proprioceptive neuromuscular facilitation (PNF) stretching have gained popularity for their potential to improve muscle function, neuromuscular control, and recovery. While these techniques are widely used in athletic training, there is limited empirical evidence specifically examining their effects on agility performance, especially among adolescent female football players in youth academies [3]. Coaches and trainers working with this population require evidence-based strategies to design training programs that address their unique physiological characteristics and developmental needs [4]. Furthermore, studies suggest that young female athletes respond differently to training interventions due to factors such as neuromuscular control, injury risk profiles, and the effects of puberty [5][6]. Therefore, this study aims to investigate and compare the individual and combined effects of foam rolling and PNF stretching on agility and muscular endurance performance among female players from the U17 Negeri Sembilan Football Club (NSFC), to fill a critical gap in the current sports science literature and support the development of more targeted training practices.

II. METHODS

A. Subjects

The study involved twenty trained female football players from the Negeri Sembilan Football Club (NSFC) Under-17 (U17) team. Participants were randomly assigned to two intervention groups: the Foam Rolling (FR) group ($n = 10$) and the Proprioceptive Neuromuscular Facilitation (PNF) stretching group ($n = 10$). Before participation, written informed consent was obtained from all participants, ensuring voluntary involvement in the study.

Inclusion criteria required participants to be female football players registered with the NSFC U17 team, aged

below 17 years, and actively participating in regular football training for a minimum of six months. All participants were required to be in good physical health, free from musculoskeletal injuries, and without any known history of metabolic, cardiovascular, or pulmonary disorders.

B. Instrumentation

Agility

The Illinois Agility Test was used to measure change-of-direction speed, which is important in football [1][7]. The test was done on a 10 m × 5 m course with cones, and time was recorded using a stopwatch. Each participant completed one trial. This test is reliable for football players ($ICC = 0.89–0.93$) [8]. Agility was tested before the intervention and again 72 hours after to assess changes.

Muscular Endurance

Muscular endurance was measured using the 1-minute push-up test, which assesses upper-body endurance important for football [9]. Participants performed as many correct push-ups as possible in 60 seconds, keeping a straight body line and full range of motion. Two researchers recorded the total number for accuracy. This test is practical and shows a strong correlation with overall endurance in female athletes ($r = 0.82$) [10].

C. Procedure

Baseline measurements of agility (Illinois Agility Test) and muscular endurance (1-minute push-up test) were recorded for all participants. Players were then randomly assigned to either the Foam Rolling (FR) or PNF stretching group. The FR group completed a 15-minute session targeting five lower-body muscle groups: calves, quadriceps, hamstrings, iliotibial band, and glutes. Each muscle was rolled for 30–45 seconds with 15-second rest intervals, applying moderate pressure (rated 5–7 on a 10-point discomfort scale) [11]. The PNF group performed assisted hold-relax-contract stretches consisting of a 10-second passive stretch, a 6-second isometric contraction at 75% effort, and a 30-second deeper stretch [12]. Agility and muscular endurance were reassessed immediately after the intervention, as well as at 24 and 72 hours post-intervention to measure both short- and longer-term effects.

D. Statistical Analysis

A randomized controlled trial design was used to compare the effects of Foam Rolling (FR) and Proprioceptive Neuromuscular Facilitation (PNF) stretching on agility and muscular endurance among female U17 players from the Negeri Sembilan Football Club (NSFC). Performance data were collected using the Illinois Agility Test and the 1-minute push-up test. Prior to analysis, the dataset was screened for missing or inconsistent values, and basic data cleaning procedures were performed. Statistical analyses were conducted using JAMOVI software (version 2.3.28). Independent samples t-tests were used to compare baseline performance between the FR and PNF groups. Repeated measures ANOVA was then applied to evaluate changes in agility and muscular endurance over time within and between groups.

III. RESULTS

The results demonstrated a significant effect of both the Foam Rolling (FR) and Proprioceptive Neuromuscular Facilitation (PNF) stretching interventions on agility performance and muscular endurance across the two time points (pre- and 72 hours post-intervention). As shown in Table 1, the main effects for both the Illinois Agility Test and the 1-minute push-up test were statistically significant ($p = 0.001$), indicating meaningful performance changes following the interventions.

Further analysis revealed that the FR group showed greater improvement in agility scores, while the PNF group achieved better results in muscular endurance. These findings suggest that each intervention may offer specific benefits depending on the targeted performance outcome.

TABLE I
TEST OUTPUT

Effect	<i>p</i> value	<i>Eta Square</i>
Agility (sec)	<0.001	0.009
Muscular Endurance (<i>reps</i>)	<0.001	0.028

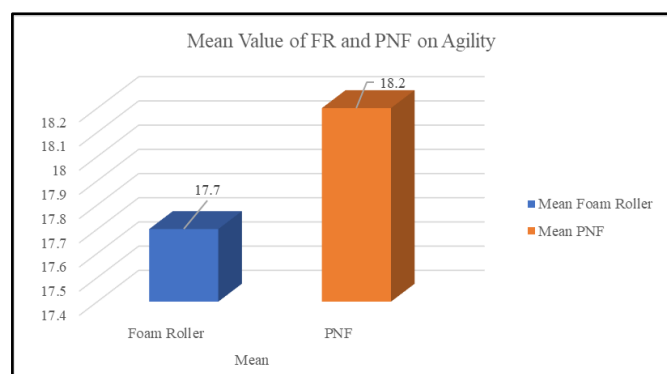


Fig. 1 Mean Value of FR and PNF on Agility.

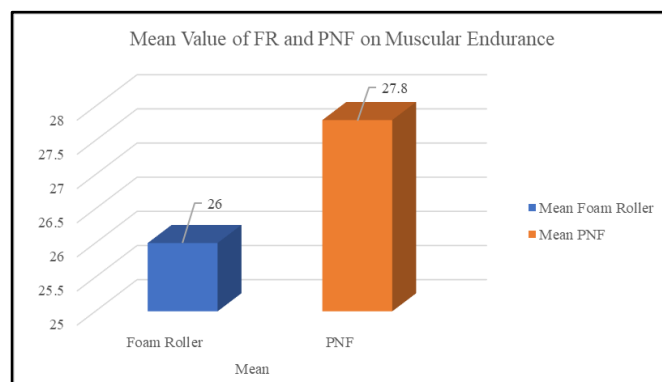


Fig. 2 Mean Value of FR and PNF on Muscular Endurance.

Figure 1 shows a difference in mean agility scores between the two groups. The Foam Rolling (FR) group recorded a lower mean completion time ($M = 17.9$ seconds) compared to the PNF group ($M = 18.1$ seconds), indicating better agility performance in the FR group, as lower times represent faster performance on the Illinois Agility Test.

In contrast, Figure 2 demonstrated that the PNF group achieved a higher mean score ($M = 27.8$ repetitions) in the 1-minute push-up test compared to the FR group ($M = 26$ repetitions), suggesting that PNF stretching was more effective in enhancing muscular endurance.

IV. DISCUSSION

This study compared the effects of Proprioceptive Neuromuscular Facilitation (PNF) stretching and Foam Rolling (FR) on agility and muscular endurance among U17 female football players from the Negeri Sembilan Football Club (NSFC). While both methods are commonly used in athletic settings to enhance performance and facilitate recovery, limited research has explored their specific effects on adolescent female athletes.

The findings demonstrated that foam rolling was more effective in improving agility performance. Participants in the FR group achieved faster times on the Illinois Agility Test compared to those in the PNF group. This supports previous studies suggesting that foam rolling may reduce muscle stiffness and improve neuromuscular coordination, thereby enhancing the ability to perform rapid directional changes as an essential skill in football [3]. The application of moderate pressure to the lower-body musculature may have contributed to increased blood flow, reduced fascial restrictions, and improved movement efficiency during agility tasks.

In contrast, the PNF stretching group exhibited greater improvements in muscular endurance, as indicated by a higher number of push-ups completed in the 1-minute test. These results are consistent with the literature that highlights the effectiveness of PNF stretching in enhancing neuromuscular control, flexibility, and fatigue resistance [13]. The hold-relax-contract method used in PNF may have facilitated greater

muscle activation and endurance capacity, particularly in repetitive upper-body movements.

Overall, the findings suggest that both FR and PNF stretching provide performance benefits but in different domains. Foam rolling may be more effective for enhancing agility, while PNF stretching appears more beneficial for improving muscular endurance. These results offer practical value for coaches and strength and conditioning professionals working with youth athletes, as interventions can be tailored to target specific performance outcomes based on training or recovery goals.

IV. CONCLUSIONS

This study concluded that foam rolling was more effective for improving agility, while PNF stretching was better for enhancing muscular endurance in U17 female football players. Both treatments had significant effects, showing that different methods work best for different performance goals. These findings can help coaches choose the right recovery strategies to support young athletes during training and competition.

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