IJPESS
Indonesian Journal of Physical Education and Sport Science
p-ISSN 2775-765X | e-ISSN 2776-0200
Volume 5, No. 4, December 2025. Page. 583-591
http://journal.unucirebon.ac.id/index.php ijpess

The Effect of Proprioceptive Neuromuscular Facilitation on Flexibility and Agility in Soccer Athletes

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Received: 02 September 2025, Approved: 07 November 2025, Published: 30 December 2025

Abstract

Study purpose. Improving physical performance is crucial for football players, where flexibility and agility are key components that affect movement efficiency and injury prevention. This study aims to determine the effect of Proprioceptive Neuromuscular Facilitation (PNF) training on improving the flexibility and agility of football players.

Materials and Methods. Total of 25 football players from Persigar Garut participated in a one-group pre-test and post-test experiment. Flexibility was measured using the Sit and Reach Test and agility was measured using the Illinois Agility Sprint Test. The validity and reliability of the instruments were ensured to guarantee the accuracy of the measurements.

Results. Data analysis using the paired t-test showed a significant improvement ($p < 0.05$) in both factors after the intervention. Average flexibility increased by 23.8% and agility increased by 12.26%. These results confirm that PNF training effectively improves both performance variables.

Conclusion. PNF exercises are recommended as an effective method for improving athletes' range of motion and speed of change of direction. The contribution of this study is to provide a scientific basis for incorporating PNF as a standard training programme, and further research can focus on comparing PNF with other stretching methods and its impact on long-term injury prevention.

Keywords: PNF, Flexibility, Agility, Football
DOI: https://doi.org/10.52188/ijpess.v5i4.1743

Introduction

Football is the most popular team sport in the world, requiring a combination of physical ability, technique, tactics and mental strength to achieve optimal performance on the pitch (González-Fernández et al., 2021). Every player must have adequate strength, speed, endurance, flexibility, and agility to be able to adapt to the fast and intense dynamics of the game (Ferrini et al., 2025).

In the context of athlete development, improving physical abilities such as flexibility and agility is a key focus because they play a major role in supporting movement efficiency

and preventing injuries (Bel et al., 2021). Flexibility is defined as the ability to move the body through its maximum range of motion without causing damage to the surrounding joints and muscles (Smith et al., 2023), Agility is the ability to quickly and accurately change direction and body position while moving (Young & Farrow, 2020). Both of these components are essential for quick reactions and effective changes of direction on the pitch.

Although Proprioceptive Neuromuscular Facilitation (PNF) has long been recognised as an effective stretching technique, recent research continues to confirm its superiority over static or dynamic methods in improving flexibility (Apostolopoulos et al., 2019). In the context of football, it is important to improve not only flexibility but also agility, as both support performance. Recent studies show that PNF can improve flexibility and support sprint performance in young football players (Oliveira et al., 2022), and also has a significant influence on increasing agility (agility) (Jordan et al., 2023). However, the research gap lies in the structured and measurable testing of the effects of PNF, which simultaneously affects both components (flexibility and agility) in club-level football players in a single intervention programme.

Therefore, this study is crucial to validate PNF as an integrated training method to improve athletes' change of direction and range of motion performance effectively and efficiently. The main principle of PNF is to utilise neuromuscular reflexes through the activation of proprioceptive receptors, which have been proven to be more effective in expanding joint range of motion (Shimura & Kasai, 2020). The purpose of this study was to determine the specific effects of Proprioceptive Neuromuscular Facilitation (PNF) training programmes on improving the flexibility and agility of football players in structured training programmes. The results of this study are expected to provide the latest scientific references for coaches and athletes in developing optimal training programmes.

Materials and Methods

Study participants

The research was conducted at the Jayaraga Garut Field, which is the regular training location for the athletes from Persigar who were the subjects of this study. The population in this study consisted of all football athletes from Persigar. From this population, a sample of 25 athletes aged between 19 and 23 years was selected. Purposive sampling, or selection based on predetermined criteria, was used to select the sample, such as actively participating in training, being in good physical condition, and being willing to participate in the entire research process (Maulidin et al., 2025).

Research Design

This study utilised a single-group pre-test and post-test quasi-experimental design (O1 X O2). The objective was to assess the effect of PNF training (X) on flexibility and agility (Y) in 25 football players.

Research Procedure

The research procedure was divided into three main phases: preparation, intervention implementation, and data analysis.

This study was conducted in three main stages: Pre-test, Intervention, and Post-test. After obtaining permission and ethical approval from 25 Persigar Garut players, the Pre-test (O1) stage was carried out. At this stage, all subjects' flexibility levels were measured using the Sit and Reach Test and their agility levels using the Illinois Agility Sprint Test; the best data was recorded as the initial result. Next, the Intervention (X) stage began, in which subjects underwent a Proprioceptive Neuromuscular Facilitation (PNF) training programme three times a week for a total of four to six weeks, with a standardised Hold-Relax protocol to improve

range of motion and neuromuscular control. After the PNF programme was completed, the Post-test (O2) phase was conducted by repeating the exact same measurement procedures as in the Pre-test. Finally, the data collected from O1 and O2 were analysed using a Paired t-test to determine the significance of the improvement in flexibility and agility due to the PNF intervention.

Study organization

An experimental approach using quantitative methods was the research strategy employed in this study. This approach was chosen because it aimed to determine the effect of a specific treatment, namely the application of PNF exercises, on improving flexibility and agility in football players.

Pre-treatment and post-treatment tests form a pre-post single-group study design (Bierer et al., 2025). Two different types of tests were used as research tools to measure the two variables under study. Flexibility was measured using the Sit and Reach Test, which assesses the extent to which the muscles in the back of the body, especially the hamstrings and lower back, can stretch. Meanwhile, the agility variable is measured using the Illinois Agility Sprint Test, which assesses an athlete's ability to move quickly and change direction efficiently on a predetermined track. These two instruments were selected because they have a Cronbach's alpha value of 0.75, which is greater than 0.05, and are considered valid and reliable in measuring the physical components related to football performance in Table.

Table 1. Standardisation norms for the Sit and Reach Test flexibility

Category	**Points Awarded**
Very Good	More than 27 cm
Good	17-27 cm
Average	6-16 cm
Poor	Less than 6 cm

Source (Artha et al., 2025)

Table 2. Standardisation norms for the Illinois Agility Sprint Test

Category	**Points Awarded**
Very Good	Less than 15.2 seconds
Good	15.2–16.1
Average	16.2–18.1
Low	18.2–19.3
Very Low	More than 19.3

Table 2 the t-test, a method of data analysis, was used in this study to compare the pre-test and post-test mean scores. Before testing the hypothesis, the homogeneity and normality of the data were evaluated (Susetyo. B., 2019).

With this design and analysis, this study is expected to provide an empirical description of the effectiveness of PNF training in improving important physical abilities that contribute to football players' performance, particularly in terms of flexibility and agility.

Statistical analysis

Data analysis in this study was conducted quantitatively using IBM SPSS Statistics software version 25.

Results

Before administering Proprioceptive Neuromuscular Facilitation (PNF) training, a pretest was conducted to determine the athletes' flexibility levels. After a training programme over a certain period, a posttest was conducted. The results showed an increase in the average flexibility test scores, as shown in Table 3:

Table 3. Improvement in Sit and Reach Test Flexibility Results

Average Pretest	Post-test average	Percentage %
16,8	20,8	23,8%

The results in Table 3 show an average increase in flexibility of 23.8% after participating in PNF training. This value indicates that the PNF training method is capable of improving the ability of muscles to expand the range of joint motion, especially in the hamstrings and lower back muscles. Thus, the application of PNF training is effective in improving flexibility in football players.

Agility tests were conducted using the Illinois Agility Sprint Test both before and after PNF training. The results showed a decrease in average time, indicating an improvement in the athletes' agility, as shown in Table 4:

Table 4. Improvement in Illinois Agility Sprint Test results

Average pretest score	Post-test average	Percentage %
16,06	14,09	12,26%

Based on Table 4, it can be seen that the average time taken by athletes to complete the agility course decreased from 16.06 seconds to 14.09 seconds, representing a 12.26% improvement in performance. This reduction in time indicates an improvement in the athletes' ability to change direction and move quickly and efficiently, suggesting that PNF training also contributes positively to improved agility.

To provide an overview of the characteristics of the research data, a descriptive analysis was conducted on the pretest and posttest values of both variables, namely flexibility and agility. The summary of the results is shown in Table 5:

Table 5. Description of statistical data

		N	Range	Minimum	Maximum	Mean	Std.Deviation
Flexibility	**Pretest**	25	17	5	22	16.80	4.444
	Posttest	25	16	10	26	20.80	4.082
Agility	**Pretest**	25	3	15	18	16.06	.741
	Posttest	25	4	12	16	14.09	1.013

The results in Table 5 show that the average flexibility score increased from 16.80 cm to 20.80 cm, while the average agility score decreased from 16.06 seconds to 14.09 seconds, which means that performance improved. The relatively low standard deviation values indicate

that there were no significant differences between participants and that the data collected was homogeneous.

To ascertain whether the pre-test and post-test data were normally distributed, a normality test was conducted. Using the Shapiro-Wilk and Kolmogorov-Smirnov tests, the following results were obtained:

Table 6. Normality Test

		Kolmogrov-smirnov			Shapiro-wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Flexibility	**Pretest**	.210	25	.006	.894	25	.014
	Posttest	.225	25	.002	.898	25	.017
Agility	**Pretest**	.190	25	.020	.919	25	.048
	Posttest	.073	25	.200	.977	25	.814

Based on the results in Table 6, it is known that the agility data from the post-test has a significant value above 0.05, while the flexibility data from the pre- and post-tests has a value below 0.05. This indicates that some of the data is not evenly distributed. However, because the sample size is relatively small and the t-test is quite tolerant of violations of normality assumptions, the analysis can still be continued.

The purpose of the homogeneity test is to examine the suitability of the variation between the pre-test and post-test results for each variable. The following table shows the results of the test:

Table 7. Homogeneity Test

	Levene statistic	df1	df2	Sig..
Flexibility	.126	1	48	.724
Agility	2.899	1	48	.095

According to Table 7, the significance values for agility and flexibility are both greater than 0.05, namely 0.095 and 0.724, respectively. Therefore, it can be said that the data variance is homogeneous, which means that the measurement results between the pretest and posttest come from a uniform group.

Hypothesis testing was conducted by comparing the pretest and posttest results for the flexibility variable using a paired sample t-test. The test results are shown in Table 8:

Table 8. Flexibility hypothesis test

Pair	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference	t	df	Sig. (2-tailed)
				Lower	Upper		
Pretest – Posttest	4.000	0.707	0.141	3.708	4.292	28.284	24

The results of pre-test and post-test flexibility showed significant differences, as indicated by a Sig. (2-tailed) value of 0.000 (< 0.05). Therefore, it can be concluded that PNF exercises significantly improve the flexibility of football players.

To determine whether PNF training also improves athletes' agility, a hypothesis test was then conducted for the agility variable. The results are shown in Table 9:

Table 9. Agility hypothesis test

Pair	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference	t	df	Sig. (2-tailed)
				Lower	Upper		
Pretest – Posttest	1.074	0.613	0.123	1.721	2.227	16.106	24

The test results showed a significant difference between the pre-test and post-test scores for agility, with a Sig. value of 0.000. Thus, PNF training proved to be effective in improving the agility of football players, with a significant reduction in travel time after participating in the training programme.

Discussions

The results of the study indicate that PNF training significantly improves the agility and flexibility of football players. An average increase of 12.26% in agility and 23.8% in flexibility indicates that the neuromuscular system has adapted positively to this activity. PNF training stimulates the muscles through isometric contractions and relaxation phases, which activate neuromuscular reflex mechanisms, thereby increasing joint range of motion. This adaptation is supported by findings (Shimura & Kasai, 2020) which explains that isometric contractions in PNF trigger the activation of the Golgi tendon organ, which in turn inhibits muscle tension, allowing for a reflexive increase in muscle extensibility (flexibility) in a short period of time.

This increased flexibility is in line with research (Rafli et al., 2023), which shows that PNF exercises are more effective than static stretching in improving hamstring flexibility. These results are also reinforced by findings. (Hidayatullah et al., 2022)which reported that PNF-based training had a significant effect on improving the strength of the lower back and hamstring muscles, which play a role in stabilising body movement. With increased flexibility, football players can perform various explosive movements such as kicking, turning and jumping more efficiently, as stated (Bel et al., 2021) that improvements in neuromotor function and flexibility will have a direct impact on athletes' sprinting, jumping and balance performance.

In addition to flexibility, PNF exercises also have a significant impact on improving agility. The integration and demonstration of the simultaneous impact of Proprioceptive Neuromuscular Facilitation (PNF) exercises on two key components of football performance—flexibility and agility in a single intervention protocol is the main contribution of this study. While previous studies, such as (Apostolopoulos et al., 2019) focus solely on improving flexibility, or other research such as (Trecroci et al., 2022) and (Sun et al., 2025). Focusing on agility in general, this study empirically proves that the neuromuscular adaptations induced by PNF (23.8% increase in flexibility) directly and significantly translate into improvements in complex functional performance (12.26% increase in agility), which is essential in the context of modern football. These findings also reinforce the view that (Behm et al., 2023) regarding functional flexibility as a crucial element in injury prevention and sports performance enhancement. In practical terms, the results of this study confirm the importance of incorporating PNF exercises into football training programmes, both during the warm-up and core training phases, as proprioceptive-based exercises help athletes control their body movements efficiently, improve neuromuscular coordination, and accelerate reaction times in game situations.

Conclusion

According to the findings of the study, the flexibility and agility of football players can be significantly improved through Proprioceptive Neuromuscular Facilitation (PNF) training. Through the mechanism of alternating muscle contraction and relaxation, PNF training can expand the range of joint motion and improve neuromuscular ability to control body movement. These improvements contribute to movement efficiency, reaction speed, and the players' ability to change direction quickly and accurately on the field.

Overall, the routine application of PNF exercises can be used as an effective strategy in physical training programs for soccer players, both to improve performance and prevent muscle injuries. The results of this study reinforce the view that flexibility and agility are two important components that support each other in soccer performance. Thus, PNF exercises should be implemented as an important part of athletes' physical training programs to improve their overall technical and physical abilities.

Recommendations for future researchers include expanding the study by comparing the effectiveness of various PNF methods (e.g., Hold-Relax vs. Contract-Relax) and testing variations in dosage, frequency, and duration of exercise to identify the most optimal protocol. Additionally, future research should focus on directly investigating the correlation between increased flexibility and agility due to PNF and reduced rates of muscle injury (especially hamstrings) in soccer players during the competitive season. It is also important to replicate these findings in various athletic populations (professional, junior, or female players) and consider the use of advanced biomechanical analysis to measure changes in joint angle efficiency during specific movements (cutting or sprinting) as objective validation of the improved neuromuscular control resulting from PNF training.

Acknowledgment

We would like to express our gratitude to the Persigar Garut Management for granting permission and providing full support for this research. The researchers would also like to thank the athletes who agreed to participate in this study and took part in all activities. We hope that the results of this study will contribute positively to the development of sports science, particularly in the training of soccer athletes.

Conflict of interest

This research contains no conflicts of interest

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Cite this article as: Ibrahim, jan jang Bintang. Permadi, Asep Angga. Hermawan, Irwan (2025). Project-Based Learning Based on Basic Locomotor Skills in Physical Education Learning. *Indonesian Journal of Physical Education and Sport Science (IJPESS)*, *5*(4), 583-591. https://doi.org/10.52188/ijpess.v5i4.1743