



The differences between static stretching and proprioceptive neuromuscular facilitation stretching on flexibility: A gender review

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Abstract: Proprioceptive neuromuscular facilitation (PNF) is the latest method used in flexibility training. This study shows something different from other studies. The purpose of this study was whether there were differences in flexibility in male and female students as a result of the static stretching training method and the PNF stretching training method. The samples in this study were 80 male and female students, which were taken randomly from the male population of 56 people and the female population of 45 people, so that a total of 101 people. The results showed that the two methods showed a significant improvement. However, the PNF stretching training method was more effective than the static stretching training method in increasing flexibility. Both applied to male students and female students. Although the PNF stretching training method has been proven to increase flexibility in both males and females, students and physical education teachers need to pay attention to this training method and do it regularly and continuously by considering the advantages and disadvantages of each method. The suggestions for further research are to carry out further, complete research, which is related to this research, by taking into account the essential differences between males and females, such as physical and physiological growth and development.

Keywords: PNF stretching, static stretching, flexibility, gender.

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INTRODUCTION

Experts in recent times through the International Olympic Committee's (IOC's) recommend that the goals achieved in sports coaching are to improve physical and mental conditions, or foster health and physical fitness, and promote sports activities to achieve sports quality. (Purcell et al., 2019).. It can be seen how important the meaning contained in the sport is, both for the individual and the wider community, in addition to improving physical fitness and improving achievement. (Sebbens et al., 2016). Besides that, there are different human tendencies in terms of skills and ability to manage body activities to exercise, and the ability to improve the components of physical condition regularly to improve and or maintain physical fitness (Dohsten et al., 2020). Physical education is a structure of a whole form of learning, emphasizing the development of physical abilities, motor skills, abilities involving awareness, self-control, and social skills, through good and bad actions (Bangun et al., 2023). Physical education in secondary schools is compulsory in the UK until age 16. Therefore, effective physical education programs must influence adolescent development (Green, 2020). Students see sports as a non-academic breakthrough. Students think that academic learning is very boring for them. Therefore, they need sports activities to reduce academics boredom (Blegur et al., 2023)..



Physical education is considered more important in improving mental health and well-being due to the academic demands of school (Hemingway et al., 2023).

The study results show that most school-age children who participate in physical education learning activities, especially from junior high school to university age, often do not show a flexible form of movement that is as expected. They look stiff and rough so that the learning process that should be completed quickly turns out to be the opposite (Lee et al., 2021; Parker et al., 2022). This can be seen when following athletic subjects, namely in jumping and throwing numbers (Gomez et al., 2018) and game subjects, especially small ball games such as table tennis (Han & Wang, 2023) and badminton (Kim, 2017) as well as the flick of the wrist when smashing and relying. In the big ball games, namely soccer and basketball, which demand a lot of agility movements such as sudden reversal of direction, slack movements, outwit or try to avoid the opponent's ambush, they look very stiff even though the forms of movement have been well mastered, and carried out with fast and agile, but still looks rough. (Wann et al., 2008; Eggers et al., 2020). It is also clearly seen in subjects that demand much flexibility, such as self-defense (Koerner & Staller, 2020) and gymnastics (Roure et al., 2019)..

On the other hand, there are very striking differences between males and females in their activities. Males with their speed and agility, while females with relaxed and powerless movements. (Wellard, 2006). They have their advantages and disadvantages in following the same subjects. However, they still show an incomplete movement quality (Horicka et al., 2014).. There is another exciting thing. Some students in village schools look more rigid than students in city schools in digesting the subject matter seen from the quality of movement (Byun et al., 2012). Factors that affect the quality of rural students compared to urban students are difficulty adapting to the learning environment, lack of learning support facilities, expansion of social and academic opportunities, and accessing learning resources (Abankina et al., 2012). The results of other analyzes assume that it may be due to the flexibility factor. The American College of Sports Medicine explains that flexibility is the ability to move muscles and joints in all movement areas (Dantas et al., 2011). Flexibility is the possibility of movement in the area of joint motion or a group of joints (Vergeer & Roberts, 2006). Thus, it can be explained that a flexible person is a person who has a wide range of motion in his joints and has elastic muscles. People who are stiff and inelastic muscles usually have a limited range of motion in their joints (Pamboris et al., 2018). Therefore, the main factor that helps determine flexibility is muscle elasticity (Miyamoto et al., 2018).. Flexibility is essential in almost all sports, especially sports that require much joint motion, such as gymnastics, ball games, wrestling, and karate. (Chaabène et al., 2012). Flexibility is also vital for people of all ages, especially the elderly. The older a person gets, the stiffer the ligaments and tendons become, reducing their flexibility (Wallmann, 2009). Flexibility is one of the components of physical fitness needed to integrate various components of physical condition. It is beneficial for everyone, both male and female, from children to the elderly, especially in carrying out their daily activities (McConnell et al., 2017).

Flexibility can be developed through muscle stretching exercises and exercises to expand the range of motion of the joints (Hwang, 2018). Without regular stretching training, the muscles tend to be less flexible, so that when you have to perform harder than usual, such as in an emergency, the muscles lose their ability, resulting in injury (Roylance et al., 2013). Several stretching training methods that can be used to develop flexibility include: 1) Active stretching training method, which consists of: (a) static stretching training method (static method), (b) ballistic stretching training method), 2) Passive stretching training method, and 3) Combination method or proprioceptive neuromuscular facilitation (PNF) (Gao et al., 2019; Loturco et al., 2020). Each stretching method has its way and characteristics. However, some studies believe that static stretching and PNF stretching are superior to dynamic stretching in improving flexibility (Nakamura et al., 2021). However, there is debate about whether static stretching can jeopardize athletic performance (Song et al., 2018). Many people debate whether there is a difference between static stretching and PNF stretching. Many studies show that PNF stretching improves function and pain relief more than static stretching (Birinci et al., 2019) and improves hip, shoulder and back flexibility (Wicke, 2014). In addition, PNF stretching improves mobility, movement control and joint synergy (Choi et al., 2022). Repetitive PNF training can improve post-stroke patients muscle thickness, dynamic balance, and gait (Alashram et al., 2021). By doing stretching exercises effectively can help to, 1) Improve one's physical fitness, 2) Optimizing the capture, training and performance of athletes in various forms of trained movement, 3) Improve

mental and physical relaxation. 4) Promotes the development of body awareness. 5) Reduces the risk of joint and muscle injury (cramps). 6) Reduces the risk of back injury, 7) Reduces muscle pain. 8) Reducing excruciating pain during menstruation (dysmenorrhea) for female athletes, 9) Reducing muscle tension. (Tsolakis et al., 2010).

The process of stretching training that is carried out regularly and correctly is beneficial in obtaining convenience in daily activities and exercise. However, this is very unfortunate because what is recommended above has not fully shown significant signs, both in terms of understanding, application techniques and forms of stretching movements. Both applied to males and females. This may be due to several factors, namely: 1) There is often a confusion of perception and understanding about warming up and stretching. 2) Lack of understanding of the application techniques behind the increasing flexibility of athletes. 3) Limited knowledge and experience in implementing stretching movements according to the specifications of the sport. 4) There is no accurate classification regarding implementing the forms of stretching movements between the static stretching method, the dynamic stretching method, the passive stretching method. The stretching method (PNF), 5) For the existing sports, several sports can be used to reduce the level of flexibility and irregular forms of training. 6) For motor skills, it turns out that there are differences between one student and another, or one athlete and another. The same goes for males and females. 7) Of each of the above stretching training methods, there may be a stretching training method that is more effective in increasing flexibility. The urgency of this research brings up stretching training method has its advantages and disadvantages. Furthermore, to determine the effectiveness of a training method, research is still needed. Likewise, suppose the method is applied to different genders, namely between male and female students. In that case, this may be due to differences in biomotor abilities, bone shape, muscles, and gender. These are some of the main problems behind why this research is necessary. The purpose of this study was whether there were differences in flexibility in male and female students as a result of the static stretching training method and the PNF stretching training method.

METHODS

The research design used in this study is a two factorial design. The research method used in this research was the field experiment method. This is following the opinion that experimenting in a broad sense is experimenting to see something results. These results will confirm how the position of the causal relationship between the variables investigated. As many as 101 9th-grade students participated in this research. Thus, the process of sampling from the population in this study was as follows: 1) The samples in this study were 80 male and female students taken randomly (with the same size and color of the sheet of paper) from a total male population of 56 students and a female population of 45 students, (101 students in total). The students were at the age between 12-14 years that consisted of males and females. Some were in illness, some recently recovered from illness, and the others were injured. (a) The samples were divided into four treatment groups which were carried out randomly. Thus, four groups were formed consisting of 20 students. The group units formed were 1) males in group A were given static stretching training, 2) males in group B were given PNF stretching training, 3) females in group A were given static stretching training, and 4) females in group B were given PNF stretching training.

Table 1. Research Design

Gender	Training Method	
	Static (B) ₁	PNF (B) ₂
Male (A) ₁	A B ₁₁	A B ₁₂
Female (A) ₂	A B ₂₁	A B ₂₂

Notes:

A B₁₁ = Score of male gender with static stretching training

A B₁₂ = Score of male gender with PNF stretching training

A B₂₁ = Score of female gender with static stretching training

A B₂₂ = Score of female gender with PNF stretching training

The stages of implementation taken in this research were as follows.

- a. Preparation phase; 1) Preparing research instruments; 2) Arrange a committee, contact, and explain the research implementation process; 3) The committee collects data and identifies it through biodata, including age and health history. Therefore, the status of students and the opportunity to participate in the research process in question is known; 4) Random sampling of 80 students from a total population of 101 students and determining the group and type of treatment; 5) Measure the height and weight of 80 samples; 6) Preliminary research for one week. It was done to introduce the techniques of static stretching and PNF movements.
- b. Implementation stage; 1) The training took place over several months, with three training sessions per week. The total number was 24 times of training; 2) Static stretching training group performed 3 days a week; 3) The training system consisted of warm-up training, core training, and calming training; 4) The training was carried out under intensive supervision from the instructor and training supervisor; 5) Doing the test after every 6 training sessions so that there were 3 mid-tests and 1 post-test. The three times the mid-test were carried out only for correction and preparation for increasing the training load. Meanwhile, the post-test was used for data processing and analysis; 6) The post-test was done after the completion of the training program.
- c. Final Stage; 1) The event of releasing and handing over souvenirs; 2) The submission of research results to the Ministry of National Education of Nganjuk Regency and Pubic Junior High School 2 Rejoso, Rejoso District, Nganjuk Regency, East Java Province.

The data obtained must be processed and analyzed to test whether the research hypothesis can be accepted or rejected. The analytical technique used was two-way ANOVA with the assistance of SPSS 16.

RESULT AND DISCUSSION

Analysis of the differences in training results between static stretching training method and PNF stretching training method.

An analysis of variance (ANOVA) was used to determine differences in training results between the static stretching training method and the PNF stretching training method and between males and females. Before doing ANOVA, the prerequisites for ANOVA were carried out with normality and homogeneity tests as follows.

a. Normality test.

The normality test of the data about flexibility was carried out to the four groups. The data processing was the difference between the pre-test and the post-test. (the calculations can be seen in appendix A) as follows.

Table 2. Normality Test Results

Test Variable	χ^2 Count/Cm	χ^2 Table	Interpretation
Static Male	0.79	3.84	Normal
Static Female	0.08	3.84	Normal
PNF Male	1.82	3.84	Normal
PNF Female	-1.425	3.84	Normal

Table 2 shows that χ^2_{count} from each group is smaller than χ^2_{table} ($\chi^2 < \chi^2_{0.95} = 3.84$) thus, the data on student flexibility training is normally distributed.

b. Homogeneity Test

After the normality test, the variance similarity of $S_1^2, S_2^2, S_3^2,$ and S_4^2 was tested simultaneously with Bartlett's test. For variances similarity testing, the hypothesis was formulated as follows:

$$H_0 : \sigma_1^2 = \sigma_2^2 = \sigma_3^2 = \sigma_4^2 \text{ (All variances are the same)}$$

$$H_1 : \text{(Not all variances are the same)}$$

Ho is rejected if $b_{\text{count}} < b_{\text{table}}$. According to appendix A, it was obtained that $b_{\text{count}} = 0.9502 > b_{\text{table}} = 0.9003$, then Ho is accepted.

Because the conditions for normality and equality of variance were met. For the ANOVA test, the following hypothesis was formulated.

a. Method Factor Effect: $H_0 : \mu_{A1} = \mu_{A2}$

$$H_1 : \mu_{A1} \neq \mu_{A2}$$

b. Effect of Gender Factor: $H_0 : \mu_{B1} = \mu_{B2}$

$$H_1 : \mu_{B1} \neq \mu_{B2}$$

c. Interaction between Method and Gender

H_0 : The effect of the method factor is independent of the gender factor, and the effect of the gender factor is independent of the method factor.

H_1 : The effect of the gender factor depends on the method factor, and the method factor depends on the gender factor.

Data processing based on attachment A is presented in Table 3.

Table 3. Two-Way Anova Summary Table

Source Variation	Amount Square	DB	Mk	Fh	Ft
Between A	3615.579	1	3615.579	27.212	
Between B	3472.347	1	3472.347	26.134	3.984
Between AB	3395.618	1	3395.618	25.556	
In (d)	-10097.942	76	-132.868		
Total (T)	405.18	79			

Table 3 shows that:

1. For Factor A. $F_{count} = FA1A2 = 27.212 > F_{table} = 3.984$. Thus, it can be concluded that H_0 : is rejected at a significance level of 5%. It means that there is a significant difference in the results of student training in terms of training methods (static and PNF).
2. For Factor B. $F_{count} = FB1B2 = 26.134 > F_{table} = 3.984$. Thus, it can be concluded that H_0 : rejected. This means that there is a significant difference in the results of student training in terms of gender (male and female).
3. For Factor AB (interaction). $F_{count} = FA1A2xB1B2 = 25.556 > F_{table} = 3.984$. Thus, it can be concluded that H_0 : The effect of the method factor (static and PNF) does not depend on the gender factor (male and female), or the effect of the gender factor does not depend on the method factor. This means that there is an interaction between gender and training methods.

From the results of data analysis, it is concluded that the results of students' stretching training by applying the static stretching training method and the PNF stretching training method can increase students' flexibility by 6.52. Stretching training carried out in a developmental stretch tone and 10-30 seconds will achieve progress beyond the previous limits of ability (Stevanovic et al., 2019). Furthermore, through the ANOVA test, it was found that the results of the training of the two methods (static and PNF) showed significant differences. However, it appears that the PNF stretching training method is superior to the static stretching training method. This is under previous findings, which suggested that the PNF method was more effective than the static method in improving range of motion (Birinci et al., 2019). The PNF method has more significant advantages and benefits than other conventional methods. It is also the best method for developing body flexibility (Borges et al., 2017). PNF is one approach that has been used conventionally in post-stroke rehabilitation. PNF is a form of neuromuscular re-education that involves stimulating sensory receptors to provide information about body position and movement to facilitate desired movements (Cayco et al., 2017). PNF also known by its founder, Herman Kabat, was developed by him with American Physiotherapist Margaret Knott in the 40s (Silva et al., 2015).

PNF stretching effectively increases and maintains a range of motion (ROM), increases muscle strength and explosive muscle power, and improves athletic performance, especially after

exercise. It is also routinely and consistently must be followed to achieve and maintain the benefits of the PNF technique. PNF is used to increase the range of motion. However, little research has been done to evaluate the other theories behind it. When this stretching technique is performed consistently in the post-exercise, it can improve the athlete's performance and a wide range of motion. PNF aims to increase range of motion and performance and demonstrates potential benefits if performed correctly and consistently (Hindle et al., 2012). PNF is used to increase muscle intensity, proprioception, active range of motion, force, motor control, and the PNF technique has been shown to increase the amplitude of contractions that occur during maximum contractions in the swallowing phase (Sayaca et al., 2020).

Another result showed that the PNF stretching training and static stretching training methods were equally effective in improving both chronic and acute hamstring flexibility of recreationally active and sedentary adults. Physical therapy can efficiently use any of these methods (Borges et al., 2017). Within the context of rehabilitation, PNF is a stretching technique used to increase muscle elasticity based on human anatomy and neurophysiology principles. This technique accelerates the response of neuromuscular mechanisms (Hindle et al., 2012) and improves physical performance through the spiral and diagonal movements to promote responses by muscle activation, as an element in the rehabilitation process of many conditions and injuries (Gontijo et al., 2012).. The results of another study using two methods, namely PNF and instrument-assisted soft tissue mobilization (IASTM), are more effective in static stretching for hamstring flexibility (Gunn et al., 2019). PNF is beneficial for older women in increasing lower leg muscle strength for gait, postural stability, and performance of activities of daily living. PNF can be used with a preventive or curative perspective because of its low cost, easy implementation, and suitability for the elderly (Carvalho et al., 2017). The position of the participants and movement sequence as well as the PNF Cluster, are represented in Figure 1.



Figure 1. PNF Stretching Exercise Method (Hamstring Muscle Stretch Contract Exercise)

Starting position:

The athlete lies prone on the floor with both arms folded towards the chin.

Movement form:

1. The athlete bends the leg towards the top of the 90-degree position.
2. The coach or friend takes a position at the bottom (feet) and places both hands on the Athlete's ankles.
3. The athlete makes a pulling motion towards the head to stretch the hamstring muscles, while the coach or friend tries to hold according to the athlete's ability, or vice versa, the athlete makes the pulling motion while the coach holds.
4. Perform an isometric contraction for 6-15 seconds.
5. The athlete turns over on his/her back, then the coach/friend bends the athlete's upper leg by holding the knee from top to bottom until the thigh touches the abdomen, while the other hand is placed on the athlete's heel.
6. The coach moves/lifts the athlete's leg slowly to stretch the hamstring muscle that was previously contracted isometrically earlier.
7. The stretching motion is performed to the maximum point signaled by the "stop!" call and lasts up to 10-30 seconds.

8. Perform the same movement on the left and right limbs.

The other finding in this study is that the training results of male and female students were significantly different. This means that the results of this study are in line that females have better flexibility than males in all parts of their bodies (Carvalho et al., 2017). This means that the results of this study are in line with the opinion expressed by Carvalho et al. (2017) that females have better flexibility than males in all parts of their bodies. Furthermore, it was also concluded that there was an interaction between the stretching training method (static and PNF) and gender (male and female). This means that there is good cooperation between the two factors in increasing student flexibility.

CONCLUSSION

Based on the results of research and data analysis, some conclusions can be drawn: 1) Numerically, the results of student training increased in various ways. Likewise, with hypothesis testing, it was found that the application of the static stretching training method and the PNF stretching training method can increase the flexibility of students, both male and female. 2) The PNF stretching training method is more effective than the static stretching training method in increasing flexibility for male and female students. This can be seen from the average difference in the increase in each group; ie static male group = 4.7 < PNF male group = 6.935, and static female group = 5.99 < PNF female group = 8.425. 3) The results of flexibility training for female students were better than male students, with the application of the static stretching training method and the PNF stretching training method. This can be seen from the average difference in the increase in each group. Namely, the female group with the static stretching training method = 5.99 > the male group with the static stretching training method = 4.7 and the female group with the PNF stretching training method = 8.425 > male group with PNF stretching training method. 4) The training method depends on gender, and gender depends on the training method in increasing the flexibility of students, both male and female, or there is an interaction between the stretching training method (static and PNF) and gender (male and female).

Based on the research findings and conclusions, the following recommendations are put forward. 1) Because the static stretching training method and the PNF stretching training method have been proven to increase flexibility in both males and females, students and physical education teachers need to pay attention to this training method and do it regularly and continuously by taking into account the advantages and disadvantages of each method. 2) physical education teachers should prioritize the PNF stretching training method as a flexibility training method since it is considered that this training method is effective in increasing flexibility and important for everyone and all ages. 3) further research can be done by taking into account the essential differences between males and females, such as physical and physiological growth and development.

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