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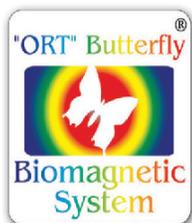
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PNF stretching and static stretching exercises: Efforts to increase the flexibility of the hamstring muscles in futsal players

Ćwiczenia rozciągające PNF i rozciąganie statyczne: działania zwiększające elastyczność mięśni uda u futsalistów

Riyan Jaya Sumantri^{1,2(A,B,C,D,E,F,G)}, Soegiyanto^{3(A,B,C,E)}, Rumini^{3(A,D,E)}, Heny Setyawati^{3(A,B,D)}, Didi Suryadi^{4(D,E,F)}, Mikkey Anggara Suganda^{5(E,F,G)}

¹Doctoral Program Pedagogy of Sport, Universitas Negeri Semarang, Indonesia

²Department of Physical Education, Faculty of Teacher Training and Education, Ma'arif Nahdlatul Ulama University Kebumen, Indonesia

³Postgraduate Doctoral Program Sports Pedagogy, Universitas Negeri Semarang, Indonesia

⁴Department of Sports Coaching Education, Faculty of Teacher Training and Education, Universitas Tanjungpura, Pontianak, Indonesia

⁵Department of Physical Education, Health and Recreation, Universitas Nahdlatul Ulama Cirebon, Indonesia

Abstract

Study Purpose. Poor hamstring muscle flexibility is one of the most common risk factors for hamstring injuries. This is due to tension in the musculotendinous structures which reduces the ability of the muscles to extend rapidly without injury. Therefore, this study aims to prove the effect of using PNF stretching and Static stretching exercises on the level of flexibility of the hamstring muscles in athletes. **Materials and Methods.** Researchers used Quasi Experimental Design research procedures. This form of design is a development of true experimental design. After being divided into two, the sample will undergo an exercise program like usually given by the coach and after the practice session cooling down sample will be given two treatments, namely the group with treatment Static stretching And group Which other get treat the PNF Stretching exercise. The subjects of this study were Futsal athletes at SMA Negeri 4 Metro using purposive sampling so that there were 20 athletes. Furthermore, data analysis in this study was assisted using the SPSS 26 application. **Results.** The results of the study obtained the results that there was a significant effect on PNF stretching on the level of muscle flexibility of futsal athletes, namely $0.000 < 0.05$. The results show an increase in the degree of flexibility of the torso by 19.5%. In Static Stretching, it shows a significant increase in the level of flexibility of the muscles of Futsal athletes, namely $0.000 < 0.05$ by showing an increase in the degree of flexibility of the torso by 6.7%. Furthermore, there is no significant difference between PNF stretching and static stretching in increasing the hamstring flexibility of futsal athletes. **Conclusions.** The results of this study provide evidence that the PNF Stretching and Static Stretching exercises both have a significant effect on the results of hamstring muscle flexibility. That way, the results of this study can be applied in efforts to prevent injuries in sports. Researchers recommend the application of PNF Stretching and Static Stretching can be done regularly in sports coaching.

Keywords

PNF stretching, static stretching, hamstring flexibility, futsal games

Streszczenie

Cel. Słaba elastyczność ścięgna mięśnia podkolanowego jest jednym z najczęstszych czynników ryzyka urazów ścięgna mięśnia podkolanowego. Wynika to z napięcia w strukturach mięśniowo-ścięgnistych, które zmniejsza zdolność mięśni do szybkiego rozciągania bez urazów. Dlatego niniejsze badanie ma na celu wykazanie wpływu ćwiczeń rozciągających PNF i rozciągania statycznego na poziom elastyczności ścięgien mięśni podkolanowych u sportowców.

Materiał i metody. Badacze wykorzystali procedury badawcze Quasi Experimental Design. Ta forma stanowi rozwinięcie projektu eksperymentalnego. Po podziale na dwie grupy, uczestnicy otrzymali program ćwiczeń realizowany pod okiem trenera. Po odpoczynku po sesji treningowej uczestnicy realizowali dwa programy: rozciąganie statyczne oraz ćwiczenia rozciągające PNF. Uczestnikami badania było 20 futsalistów z SMA Negeri 4 Metro wybranych przy użyciu celowego doboru próby. Ponadto analiza danych w tym badaniu była wspomagana aplikacją SPSS 26.

Wyniki. W wyniku przeprowadzonych badań uzyskano wyniki wskazujące na istotny wpływ ćwiczeń rozciągających PNF na poziom elastyczności mięśniowej futsalistów, mianowicie $0,000 < 0,05$. Wyniki wskazują na wzrost stopnia elastyczności tułowia o 19,5%. W przypadku rozciągania statycznego wyniki wykazują na znaczny wzrost poziomu elastyczności mięśni futsalistów, mianowicie $0,000 < 0,05$, oraz wzrost stopnia elastyczności tułowia o 6,7%. Co więcej, nie ma znaczącej różnicy między ćwiczeniami rozciągającymi PNF a rozciąganiem statycznym w zwiększaniu elastyczności ścięgna mięśnia podkolanowego u futsalistów.

Wnioski. Wyniki tego badania dostarczają dowodów na to, że zarówno ćwiczenia rozciągające PNF, jak i rozciąganie statyczne mają znaczący wpływ na wyniki elastyczności ścięgien mięśni podkolanowych. W ten sposób wyniki tego badania mogą być stosowane w celu zapobiegania urazom w sporcie. Badacze zalecają regularne wykonywanie ćwiczeń rozciągających PNF i rozciągania statycznego w treningu sportowym.

Słowa kluczowe

ćwiczenia rozciągające PNF, rozciąganie statyczne, elastyczność ścięgien podkolanowych, gra w futsal

Introduction

Sport is a physical activity that is easy for everyone to do [1, 2]. However, in sports activities people sometimes underestimate several aspects of preparation for exercise such as warming up, core training and cooling down [3]. This aspect plays a very important role in sports activities, especially in injury prevention [4]. Lack of warm-up is one of the causes of injury in sports [5]. These injuries cause activity disturbances which will cause movement and function disturbances [6]. Injuries that are quite common during sports [7], including strains on the hamstring muscles [8]. Strain is damage to muscle tissue due to direct (impact) or indirect (overloading) trauma or tearing of muscles and tendons due to being stretched beyond normal limits or excessive contraction [9, 10]. Hamstring strain will cause several problems such as pain, limitation of joint range of motion, muscle spasm [11].

In addition, if there is a hamstring muscle injury it will affect the explosive power of the lower leg muscles because the muscles become weak [12, 13]. A study by [14] states that in stop and go sports such as football, Australian Rules Football, Rugby, hamstring muscle injuries are the most common injuries. Likewise in the German Bundesliga, muscle strains, muscle contractures or tendon problems in the hamstring muscles. Furthermore, in American Football, 41% of total injuries are hamstring injuries, and under Australian Rules Football, the prevalence is estimated at 16% [14]. Woods et al explained that 12% of injuries to professional football players are hamstring strains [15]. Hamstring injuries usually result in a significant reduction in competition and training time. Reduced flexibility is a risk factor for muscle injury. Treatment to increase flexibility has been used since 1980 by physiotherapists, athletes and trainers, namely stretching techniques [14]. It was stated by [16] that reduction of muscle injury was demonstrated when stretching was performed.

While in Indonesia, based on research, it is recorded that an athlete experiences two injuries on average every season and the most cases [17], including 12% of hamstring injuries, followed by 9% of MCL injuries and 7% of quadriceps injuries. The shortening of the hamstring muscles will have an impact on the emergence of other disorders. One of them is a change in posture which can cause complaints of lower back pain due to a decrease in the balance of contracting muscles. The shortening of the hamstring muscles can increase the pressure on the patelofemoral syndrome. Furthermore, it is also stated that contractures in muscles will affect stiffness in joints by 41% and contribute to disruption of the capsule by 47% and in tendons by 10% [18].

Other research was also conducted by [19] who aims to study injuries of futsal players from Iran for one year Persian calendar on 21 March 2010 until 20 March 2011 with data sport federation medicine system surveillance injured Research This shows, over the course of one year, 1145 injuries at a rate of 8.1/1000 athletes reported by the team and competition for treatment. That injury most Lots happen on player futsal that is on member motion under the body. Based on survey in Dutch state that futsal is 10 among the sports that contribute most to the number of sports injuries and number injured on sport futsal that is 55.2 events per 10,000 O'clock futsal game played [20]. According to Australian Rules Football The most common injuries occur to the knee, ankle and hamstring, with a hamstring injury percentage rate of 16% and a prevalence of the incidence of hamstring injuries according

to American football is more than 40% [14]. So to be able to perform various movements in futsal good physical ability is required. With good physical abilities can increase performances [21–23], increase quality movement players [24], and can reduce the risk of injury during matches [10], so that will created good game, with hope get max results.

Physiotherapy is a form of health service aimed at individuals and or groups to develop, maintain and restore motion and body functions by using manual handling, increased movement, equipment (physique, electrotherapeutic and mechanical), training function, communication [25]. With these physiotherapy skills, physiotherapists can provide comprehensive treatment in terms of injuries strains hamstrings. Physiotherapy has an important role in providing direction, input, and providing training programs that can improve the physical quality of players. The physical condition that will be improved is the flexibility of the hamstring muscles. The increase in hamstring flexibility is intended so that players can move more freely on the field. Exercises to increase flexibility usually use the stretching method. Stretching is divided into two, namely static stretching and dynamic stretching. Static stretching is the most frequently used stretching method, soft tissue is elongated right past the point of tissue resistance and then maintained in an elongated position with a continuous stretching force for some time [26].

In SMA Negeri 4 Metro Futsal athletes there are members who are included in the athlete category, where the athletes are prepared by the coach to take part in various competitions. To prepare athletes to take part in competitions, coaches will train athletes as well as possible through training programs so that athletes can show their best performance in competitions. In carrying out a training program for athletes, a trainer will refer to technique, tactics, mental and physical, some of the physical components in karate including hamstring muscle flexibility. The importance of paying attention to these physical components as an effort to reduce training problems while achieving an increase in athlete's ability [22]. The problem that the author observes in the practice of SMA Negeri 4 Metro Futsal athletes is that coaches and athletes sometimes forget the physical component of hamstring muscle flexibility. In the training for Futsal athletes at SMA Negeri 4 Metro, the coach has not provided a form of exercise that can help increase the athlete's hamstring muscle flexibility. To provide this solution, researchers are interested in providing 2 treatments, namely PNF stretching and static stretching as a treatment given after exercise where this treatment is proven to increase hamstring muscle flexibility so that it is increasingly proven to have a positive effect on hamstring muscle flexibility.

For non-athletes, flexibility can support daily activities, while for athletes, such as gymnasts, diving, judo, several athletic numbers, fencing, wrestling and other sports, flexibility is needed. Flexibility is a necessary prerequisite for displaying a skill that requires wide range of motion and makes it easier to perform fast and agile movements. [27]. Early treatment of the correct hamstring strain by physiotherapy will determine condition advanced patient. Principle handling beginning on injury sport is reduction of symptoms such as pain and increased joint range of motion [28]. Thus, the physiotherapist must provide the right treatment to support patient recovery [29]. Therefore, an injury prevention warm-up program is very important for youth sports safety [5]. Thus, in the study of stretching (stretching) becomes a a form of physical exercise on

a group of muscles or tendons to flex a muscle, increase its elasticity, and obtain comfort in the muscles [30]. There are several types of stretching: static stretching, cyclic / intermittent stretching, ballistic stretching, proprioceptive neuromuscular facilitation stretching procedure (PNF stretching), manual stretching, mechanical stretching, self-stretching, passive stretching, and active stretching [31]. Based on these problems, this study aims to report handling beginning physiotherapist on patient with condition strains the hamstrings recommended in handling beginning on condition injury sport.

Research Methods

Participants

This research was conducted at the State Senior High School 4 Metro Sports Hall. Pretest and posttest data collection was carried out on November 15, 2022, and data collection. The subjects of this study were 20 futsal athletes at SMA Negeri 4 Metro. The collection of research subjects by purposive sampling was described based on age, male sex, and willingness to be given PNF stretching and static stretching exercises.

Procedure

In this study, researchers used a Quasi-Experimental Design research procedure. This form of design is a development of a true

experimental design, which is difficult to implement [32]. Where this aims to put forward "Quasi-Experimental design forms, namely Time-Series Design and Nonequivalent Control Group Design".

The first thing the researcher will do is do a pretest to know the level of hamstring flexibility before getting treatment. After doing the pretest, then the researcher is divided into two groups: Group 1 given static stretching and the second group was given PNF stretching exercises to determine the level of flexibility after being given the treatment.

After being divided into two, the sample will undergo an exercise program like usually given by the coach and after the practice session cooling down, the sample will be given two treatments, namely the group with treatment Static stretching and the group which otherwise gets the PNF stretching exercise. The two treatments will be observed by the researcher and will be measured with a tool measuring flexibility that is sit and reach.

If on the end there is a change between pretest and posttest from the experimental group, then it was caused by the effect of the PNF treatment stretching which given after program exercise. This research was conducted in 1 meeting. So that design it can be known correctly the difference in PNF treatment stretching which given to level flexibility sample. Second such treatment will be compared and will show the results where between both of them which which more effective can increase flexibility sample. Design study this can be depicted like table following.

Table 1. Study design

Group	Pretest	Exercise	Treatment	Posttest
Experiment 1	T1 ¹	O1	X1	T1 ²
Experiment 2	T2 ¹	O1	X2	T2 ²

T1¹: Group 1 (Static stretching) Pretest before exercise; T2¹: Group 2 (PNF Stretching) Pretest before practice; O1: hamstring muscle flexibility; X1: Treatment Static stretching; X2: Treatment PNF Stretching; T1²: Group 1 Static stretching Posttest; T2²: Group 2 PNF Stretching Posttest

Data Analysis

Before testing the hypothesis, it is necessary to carry out a prerequisite normality test, if the data is normal then it is tested with the t test, if not then using a non-parametric test. The data normality test in this study uses the SPSS application with the Shapiro-Wilk formula. Data analysis in this study was assisted by using the SPSS 26 application.

Results

The results of the study were described based on age, male gender, and willingness to be given PNF stretching and static stretching exercises. The results of the characteristics of the research subjects are presented in the following table:

Table 2. Data of research subjects

Category sample	Information	f(n)	Percentage (%)
Age	16	9	45
	17	8	40
	18	3	15
Amount		20	100
Weight	50–55	5	25
	56–60	8	40
	61–65	7	35
Amount		20	100
Tall Body	156–160	2	10
	161–165	4	20
	166–170	10	50
	171–175	4	20
Amount		20	100

The table above shows that there were 9 research subjects aged 16 years, 8 people who were 17 years old, and 3 people who were 18 years old. The results can be seen in Figure 1.

Based on body weight, as many as 5 research subjects have weight between 50–55 kg, 8 research subjects have weight between 56–60kg, and 7 people research subjects have a body weight between 61–65 kgs. The results can be seen in Figure 2.

Then based on the height of 2 research subjects have a height between 156–160 cm, 4 research subjects have height between 161–165 cm, 10 research subjects have height body between 166–170 cm and as many as 4 research subjects have height between 171–175 cm. The following is a characteristic data diagram sample. The results can be seen in Figure 3.

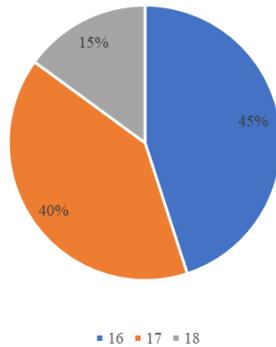


Figure 1. Characteristics of subjects based on age

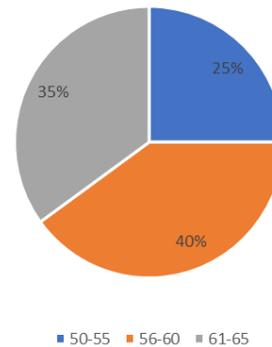


Figure 1. Characteristics of subjects based on weight

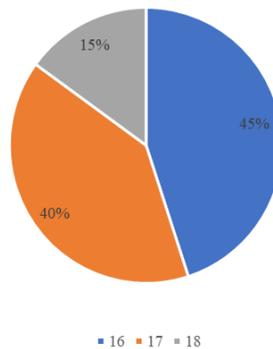


Figure 1. Characteristics of subjects based on height

Group PNF Stretching

Data obtained from results test hamstring flexibility use sit and reach before subject get treatment and after subject get treatment

(treatment) PNF stretching. Following presented n distribution frequency status hamstring flexibility futsal athletes from SMA Negeri 4 Metro before get treatment and after:

Table 4. Description of the results of hamstring muscle flexibility pretest and posttest of PNF stretching

Category sample		Information	
Criteria	F	Criteria	F
Very good	0	Very good	0
Good	2	Good	4
Enough	4	Enough	3
Not enough	4	Not enough	3
Far not enough	0	Far not enough	0
Amount	10	Amount	10

The results of the distribution of the pretest and posttest group frequency tables are presented in Figure 4.

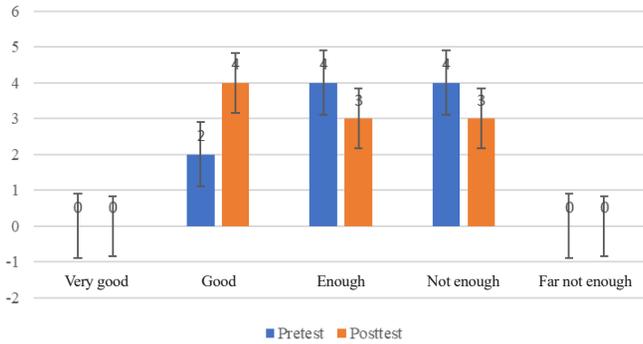


Figure 4. Hamstring muscle flexibility diagram pretest posttest of PNF stretching

Based on distribution frequency pretest data, from 10 person subject study, there was no subject with hamstring muscles flexibility in the very good level, 2 people had good hamstring muscle flexibility level, 4 people had enough hamstring muscle flexibility enough level, 4 people had not enough hamstring muscle flexibility level, and none of the subjects had far not enough flexibility muscles hamstring level. In the posttest data results: there was no subject with hamstring muscles flexibility in the very good level, 4 people had good hamstring muscle flexibility level, 3 people had enough hamstring muscle flexibility enough

level, 3 people had not enough hamstring muscle flexibility level, and none of the subjects had far not enough flexibility muscles hamstring level.

Group static stretching

The hamstring muscle flexibility test using a sitting position was examined before and after treatment with static stretching. The following is the state of frequency distribution, flexibility of the hamstring of futsal players with SMA Negeri 4 Metro before (pretest) and after (posttest) therapy.

Table 5. Description of the results of hamstring muscle flexibility pretest and posttest of static stretching

Category sample		Information	
Criteria	F	Criteria	F
Very good	0	Very good	0
Good	2	Good	7
Enough	6	Enough	3
Not enough	2	Not enough	0
Far not enough	0	Far not enough	0
Amount	10	Amount	10

The results of the distribution of the pretest and posttest group frequency tables are presented in Figure 5.

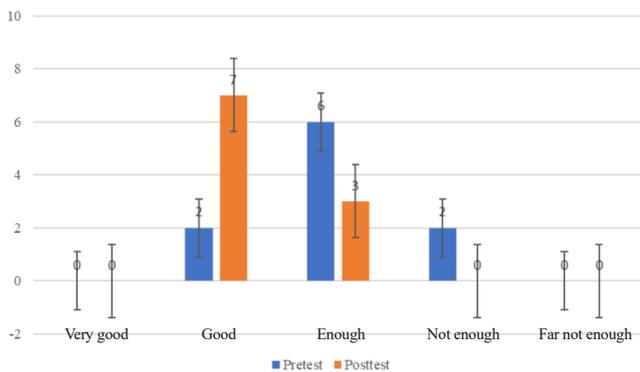


Figure 5. Hamstring muscle flexibility diagram pretest posttest of static stretching

Based on distribution frequency pretest data, from 10 person subject study, there was no subject with hamstring muscles flexibility in the very good level, 2 people had good hamstring muscle flexibility level, 6 people had enough hamstring muscle flexibility enough level, 2 people had not enough hamstring muscle flexibility level, and none of the subjects had far not enough flexibility muscles hamstring level. In the posttest data results: there was no subject with hamstring muscles flexibility in the

very good level, 7 people had good hamstring muscle flexibility level, 3 people had enough hamstring muscle flexibility enough level, and none of the subjects had far not enough or not enough flexibility muscles hamstring level.

Prior to data analysis and prerequisite tests was carried out hypothesis testing. Results test prerequisite analysis and hypothesis test is described as following.

Table 6. Result of normality test

Group	Data	Significance	Information
Group PNF stretching	Pretest	0.643	Normal
	Posttest	0.387	Normal
Group Static stretching	Pretest	0.482	Normal
	Posttest	0.421	Normal

Based on the table above, is the significance value of each data obtained pretest And post test. Obtained data show all data a is distributed normal Because significance level bigger than 0.05.

Results of test for homogeneity of variable study show that data variance of study group and control group distributed homogeneous with significance value $p > 0.05$ (Table 7).

Table 7. Results of test for homogeneity

Group	Significance	Information
Group PNF stretching	0.473	Homogeneous
Group Static stretching	0.484	Homogeneous

Table 8. Results of t-test

Pretest-Posttest	Df	Q table	Q count	P	Sig 5%
PNF Streching	11	2.69	6.580	0.00	0.05
Static stretching	11	2.69	5.392	0.00	0.05

Based on results analysis of t-test paired sample has obtained t-count (6.580) > t-table (2.69), and p value (0.000) < 0.05. The results show that the value of t-count is greater than t-table. Therefore H_a : accepted and H_0 : rejected. Thus the hypothesis reads "there is effect of PNF Streching method on Hamstring Muscle Flexibility in Futsal Athletes of SMA Negeri 4 Metro".

Based on results analysis of paired t-test sample t test has obtained: t-count (5.392) > t table (2.69), and p value (0.000) < 0.05, the results shows that the value of t-count is greater than t-table. Therefore H_a : accepted and H_0 : rejected. Thus the hypothesis reads "there is the influence of the static method stretching on Hamstring Muscle Flexibility in Futsal Athletes of SMA Negeri 4 Metro".

Discussion

The aim of this study report handling beginning physiotherapist on patient with condition strains the hamstrings recommended in handling beginning on condition injury sport. Where in this study proved the effect of using PNF stretching and Static stretching exercises on the level of flexibility of the hamstring muscles. The results of the analysis of this research show that

the PNF stretching technique is proven to provide benefits to the level of flexibility of the hamstring muscles of futsal athletes. The benefits of PNF Streching training, it is proven that t-count (6,580) > t-table (2.69), and p value (0.000) < 0.05 shows an increase in the degree of hamstring muscle flexibility by 19.5%. From the data above, according to research conducted [33] states that PNF Streching (Proprioception Neuromuscular Facilitation) is an effective form of hamstring muscle flexibility training to increase range of motion or range of motion. Supported by [34] PNF is a hamstring muscle flexibility training method that can reduce hypertonus, allow muscles to relax, lengthen and can be applied to patients of all ages. Where this statement agrees with [35] which states that the benefits of PNF stretching exercises can significantly help restore stretch reflex levels and increase relaxation in the muscles that are stretched.

Furthermore, the results of the analysis of this research show that the Static Stretching technique is proven to provide benefits to the level of hamstring muscle flexibility in futsal athletes at SMA Negeri 4 Metro. The benefits of static stretching exercises are proven by the t-count (5,392) > t-table (2.69), and the p value (0.000) < 0.05 indicates an increase in the degree of hamstring

muscle flexibility by 6.7%. From the research data, according to Utami's opinion, static stretching can reduce lactic acid levels in muscles and blood glucose levels [36]. Supported by Ningsih's research, explaining that there is a significant effect of Static Stretching on reducing lactic acid levels in male students [37]. Meanwhile, according to Juntakarn, static stretching is a method that is equally effective with stretching to increase the flexibility of the hamstring muscles in the lower back in the short term [38].

Therefore, we conclude that, if PNF stretching is used as a warm-up exercise. A target muscle-specific PSA must be followed to keep performance results at the same level while retaining the benefits of a greater range of motion [39]. The results showed that the athlete's shoulder rotation index after using the PNF stretching method was significantly lower compared to the traditional stretching method; under the PNF stretching method, the average strength and total work of the shoulder joint increased significantly in high-speed external rotation, and performance in the 50 m freestyle also significantly improved [40].

High-intensity static stretching is effective for reducing muscle unit stiffness even when a specified static stretching load is put together [41]. The load applied to static stretching is an important factor in reducing the stiffness of the muscle-tendon unit in low- and moderate-intensity static stretching, but not in high-intensity stretching. Muscle thickness significantly predicts fascicle length, which affects muscle function and performance [42]. Static stretching increases muscle length, fascicle length and flexibility, but muscle thickness and angle of pennation decrease significantly. The increase appeared to be more beneficial for the sedentary than the recreationally active participants. Likewise, chronic static stretching exercises produce marked increases in flexibility with a greater passive effect, compared to active Static Stretching [43].

From the results of research conducted by researchers on the differences in the effects of PNF Stretching and Static Stretching that have been given to Futsal athletes at SMA Negeri 4 Metro, the two treatments are very helpful for athletes when they practice marked by the statements of athletes who say their bodies feel fresh the next day after waking up and makes the body not feel stiff and sore. This can happen because when you get the PNF stretching and static stretching treatment that is given it can help improve circulation (activate the venous

pump), so that it will help speed up the removal of exercise waste from the muscles that are active during exercise.

In the PNF stretching treatment, the researchers concluded based on data analysis that PNF stretching was more effective in increasing hamstring muscle flexibility, which was marked by the ability of Futsal athletes at SMA Negeri 4 Metro, which showed a more significant difference compared to the static stretching treatment. This is because PNF stretching is more supportive because in this treatment there is maximum emphasis or stimulation on the muscles being trained, so that the potential for muscle development increases, so the flexibility of the body will also increase. Based on the description above, PNF stretching is known to be more effective in increasing the flexibility of the hamstring muscles of the body's muscles than static stretching.

Conclusion

Based on the results of the research and discussion, it has provided strong references regarding hamstring muscle flexibility, which has been listed in the discussion results. The results of the study prove that there is a significant effect on PNF Stretching in upgrading flexibility muscle futsal athletes, with showing enhancement degree degree stick flexibility as big 1 9.5%. Results using static stretching also gives a significant effect on the increase flexibility muscle futsal athlete, with showing enhancement degree degree stick flexibility as big 6.7%. Where the results of the two exercises are PNF stretching and static stretching showed that there was no significant difference in increasing the flexibility of the hamstring muscles in futsal athletes. The results of this study have provided a new reference description in increasing the flexibility of the hamstring muscles in athletes. That way, these results can be considered in sports coaching, especially in the early prevention of muscle injuries in sports. Recommendations for further research can do PNF combination research Stretching And static Stretching in an effort to improve flexibility muscle and of course using a wider population and sample.

Adres do korespondencji / Corresponding author

Riyan Jaya Sumantri

E-mail: rianjayasumantri@students.unnes.ac.id

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