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# Effect of Static Stretching and Neuromuscular Facilitation Stretching on Hamstring Flexibility of Subjunior Students

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**Abstract:** The benefits of flexibility training for performance enhancement and injury prevention have been extensively documented. The scientific evidence supporting these assertions is still in its early stages because of the myriad of factors that might influence injury and performance. Nevertheless, flexibility exercises remain a staple of most structured exercise regimens. Exercising in a variety of methods might help you become more flexible and looser. Which stretching method is better is still up for discussion. Some of the most common ways to stretch muscles are static stretching, ballistic stretching, and PNF stretching, which stands for proprioceptive neuromuscular facilitation. The researchers set out to determine how different types of stretching static and proprioceptive neuromuscular facilitation (PNF) impacted hamstring flexibility. 90 randomly named boys aged 14 to 16 studying in classes 8 and 9 of Mary Nilayam English The research was conducted at Pongummood Medium School in Thiruvananthapuram. In this study, participants were required to complete the Sit-and-Reach test to the farthest point using both hands. This test was designed to measure how flexible the hamstring muscles are. The participants were asked to sit and grasp for an object. Additionally, their test scores were used to split them into three equal groups. The experimental groups, which consisted of 30 students each, were split into two groups and given different stretching methods: static stretching and PNF stretching. Thirty people made comprised the Control group, the third and final group. Over the course of six weeks, each experimental group participated in a structured training program that met three times a week for forty minutes each session. Statistical significance was determined by comparing the pre- and post-test scores of the control and experimental groups using a t-test. The F-F-ratio was used to analyse data pertaining to the post-test scores of the control group and the experimental group on hamstring flexibility. Based on the data obtained and the constraints of the study, it was determined that a 6-week flexibility training program improved hamstring muscle flexibility. When comparing the two methods of increasing flexibility in schoolchildren's hamstring muscles, the PNF stretching approach seems to be better.

**Keywords:** Flexibility, Static stretching, Proprioceptive Neuromuscular Facilitation stretching

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## INTRODUCTION

The capacity of the tissues around a joint to relax and stretch is known as flexibility. The targeted tissues for stretching are the connective tissues around the joints, such as ligaments and fascia. In circumstances involving several muscles, it is also necessary to stretch the opposing muscles. Joint flexibility is essential for people of all ages because it helps keep discomfort at bay in and around joints. An indirect line of defence against harm is a high level of flexibility. Direct mechanical force on the kerchief might cause damage if the muscles are overtightened.

A high level of flexibility is essential for the performance of any sport or game. One way to improve and

maximise flexibility is to learn and practise the specific motions used in various sports and activities. Increasing or decreasing the range of motion around the joints might improve the effectiveness of certain chops until the desired level of flexibility is reached. Athletes can benefit from increased flexibility in order to reduce the likelihood of injury. It's worth remembering that this is only true at the most ideal level of flexibility. On the other hand, slack joints raise the danger of harm. This indicates that maximum flexibility is necessary to maximise shared stability.

The benefits of flexibility training for performance enhancement and injury prevention have been extensively documented. Almost every structured fitness regimen includes flexibility exercises. To this day, experts disagree on the best method of stretching. Exercising in a variety of methods might help you become more flexible and looser. A few of the most common ways to stretch muscles include the static variety, the ballistic variety, and the PNF kind. These exercises can be performed alone utilising simply our own muscles, strength (body weight), or the assistance of another person's body or a partner.

Ballistic stretching is associated with bouncing, rebounding, and rhythmic stirring. This kind of motion is sometimes referred to as isotonic, dynamic, kinetic, or presto stretching. Because swing motions induce the antagonist muscles to contract in a stretch reflex, which prevents them from getting the best possible stretch, this system's efficacy has been under continual scrutiny as of late. Plus, you won't have to worry as much about injuring yourself by straining your muscles too much. When you want to stretch a muscle, a good static stretch is to hold a light, comfortable stretch for 15 to 30 seconds. Holding the pose lessens the feeling of stretching. When compared to traditional stretching methods, the benefits of Proprioceptive Neuromuscular Facilitation (PNF) stretching—which involves an isometric contraction prior to stretching—are marginal at best. The innovative employment of many neurological systems to maximise the muscle's outstretching capacity allows for extremely rapid gains in flexibility. In order to increase flexibility, coaches, PE teachers, and trainers employ a wide variety of training methods. However, it is still unclear which of these training methods is best for helping athletes achieve peak flexibility. The purpose of this research was to evaluate the effects of static and PNF stretching on hamstring flexibility.

## METHODOLOGY

Ninety-one male students from Mary Nilayam English Medium School in Pongummood, Thiruvananthapuram, who were enrolled in eighth and ninth grade, were chosen at random for the research. Their ages vary between fourteen and sixteen. In the sit-and-reach test, the maximum distance that could be reached using both hands served as the criterion for the investigation. In the field, all subjects were gathered at the same time. The goals and prerequisites of the exam were reviewed with them. They were given time to prepare for the examination by warming up and practicing questions before the actual exam. Test takers were advised to give it their all regardless of the allotted time. All courses had their exams on the exact same day.

Following the steps outlined in the AAHPERD Health-Related Fitness Manual (1980), the sit-and-reach test was run. This test was designed to measure how flexible the hamstring muscles are. The sit-and-reach test calls for the subject to extend their hamstrings by reaching forward. The apparatus in question is a box with a measuring scale along the length of its front edge, which corresponds to the edge measuring 23 centimetres. To keep it from falling to the floor, the apparatus was fastened to a wall. The subjects' feet

were tied to a box and they were instructed to sit barefoot for long periods of time. The investigator instructed them to stand with their knees bent and their arms stretched forward. If they were unable to straighten their knees, they were advised to press them down. Their hands should be put on top of each other with the palms facing downward and the fingers lying on top of their fingernails. They were instructed to extend their arm straight ahead along the measuring scale four times, with each repetition requiring them to maintain the highest possible position for a minimum of one second. There is just one trial. All participants had their furthest point measured to the nearest centimetre using both hands[2]. The identical test was used to gather data both before and after the intervention. The data for the pre-test was taken on October 8, 2019, and the data for the post-test was taken on December 8, 2019, which is six weeks later. The participants were asked to sit and reach for a ball. After that, their test results were used to split them into three equal groups. Static stretching and Proprioceptive Neuromuscular Facilitation (PNF) stretching were the two stretching methods randomly allocated to the first two experimental groups of thirty students each. There were 30 people in the third group, which served as a control. Each experimental group participated in a 40-minute training session on Monday, Wednesday, and Friday for a total of six weeks. The investigator himself kept an eye on and managed this. A 5-minute warm-up was conducted before each training program.

Static stretching is holding a gentle stretch for 15 to 30 seconds while breathing normally. In between each round of exercises, participants were given ample opportunity to cool down and loosen up. Six exercises were chosen specifically to stretch the hamstring muscles as part of the training. For the training, we used the following static stretching exercises: (a) sitting hamstring stretch, (b) straddle stretch, (c) stride stand stretch, (d) straddle stand stretch, (e) one leg pull stretch, (f) one leg partner stretch, and (g) sitting hamstring stretch. By maintaining a stretch for an allotted amount of time, static stretching helps to loosen up tight muscles and open up tight joints. These six exercises were chosen for the study because they target the hamstrings, which are an area that requires training to increase flexibility. Flexibility and muscle lengthening are both enhanced by these exercises' ability to provide a continuous stretch. These stretches are simple and widely used, so even those who are just starting out in athletics may execute them. Beginning with lower-intensity activities for shorter durations, the training program gradually increased the time spent exercising at a greater intensity. The researcher had complete control over the amount and intensity of the workouts utilised for training. Several studies aimed at increasing athletes' hamstring flexibility have also made use of this series of exercises.

Proprioceptive neuromuscular facilitation (PNF) is a method of stretching that entails isometric or isotonic muscle contraction for six to seven seconds followed by a brief period of relaxation. After that, the muscle is stretched, either actively or passively, and then kept in that position for 8 to 10 seconds. Breathing is brought back to normal, and there is time for muscles to recuperate in between workouts. The hamstring muscles were stretched during the workout with six targeted movements. The Neuromuscular Proprioception Enhancement A variety of stretching exercises were used for the training, including (a) Slow Reversal (SR), (b) Repeated Contractions (RC), (c) Hold Relax (HR), (d) Contract Relax (CR), (e) Slow Reversal-Hold (SRHR), and (f) Slow Reversal-Hold (SRH). A flat surface, such as a table, is required for all activities in which the subject has to lie. At hip level with the topic, the partner stands at their side. He either moves in the subject's direction or stands in its way. Every single exercise requires the

participant to stand on one leg while keeping their knees bent at a maximum angle. Beginning in this posture, you will work both legs throughout the workout. The PNF Stretching, which includes both static and isometric contractions, is a great way to increase your flexibility and mobility. The hamstrings are the specific muscles that require strengthening in order to increase range of motion, hence these six exercises were chosen for the research. Proprioceptive neuromuscular facilitation (PNF) is the basis of PNF stretching, which involves isometric contractions and subsequent relaxation to increase flexibility and range of motion. The training program started with lower-intensity activities for shorter periods of time and worked its way up to higher-intensity exercises for longer periods of time. The trainer's volume and intensity of movement were both managed by the researcher. Additional studies aimed at increasing athletes' hamstring flexibility also made use of this series of exercises.

In the absence of any intervention, members in the control group took part in a regularly scheduled sports and PE class. As was customary, all three groups adhered to the course outline. A pre- and post-test on the criteria sit-and-reach test were administered as part of the equal group design in this study. The effectiveness of static stretching, PNF stretching, and control group training on hamstring flexibility was investigated by comparing pre- and post-test means using 't' tests. Subjects' post-test performance was evaluated using an F-ratio and a post-hoc ANOVA test in the Static stretching, PNF stretching, and control groups.

## RESULTS

We used analysis of variance to find out how the training regimen affected the flexibility of the hamstrings. Results from the data analysis followed the formula provided by Clarke & Clarke. To find statistical differences between the pre- and post-tests of the experimental and control groups, a T-test was utilised, with a significance threshold of 0.05. The F-ratio was used to assess data pertaining to the post-test scores of the control group and the experimental groups on hamstring flexibility. The significance of variations between matched means was tested using Scheffe's post hoc test. A significance test was conducted at the 0.05 confidence level on the F-ratio that was generated from the one-way analysis.

With the use of a t-test, we compared the three groups' pre- and post-test results. You can see how various stretching exercise routines affected the flexibility of the hamstrings in the tables below.

Using a t-test, we were able to compare the Static stretching group's mean pre- and post-test results. Tabulated in Table 1 are the statistical results.

**Table 1**
**Comparison Of Means Of Pre- And Post-Test Scores Of Static Stretching Group**

| Test | Mean | SD | t value | 2-tail prob. |
|---|---|---|---|---|
| Pre-test | 23.700 | 4.648 | 19.76* | .000 |
| Post-test | 32.00 | 5.650 | | |

* Significant at 0.05 1evel

t- value required at 0.05 level is 2.045 (df 29)

Table 1 displays the statistical results, which reveal that the Static stretching group had a considerably higher post-test mean (32.0) compared to their pre-test mean (23.7). In comparison to the tabulated t-value (2.045) at 29 degrees of freedom and 0.05 level of confidence, the t-value (19.76) was found to be highly significant (P<.05). Thus, there was a statistically significant increase in hamstring flexibility among those who participated in static stretching. Figure 1 clearly displays the outcome using bar graphs.

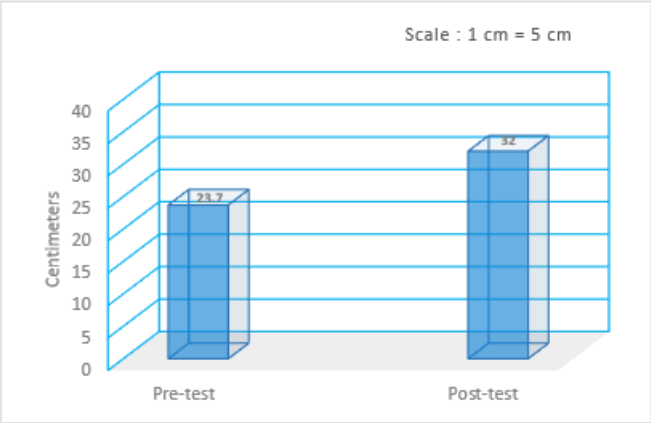


**Figure 1. Graphic Representation of Means of Pre-and Post-test Scores of Static Stretching Group**

In Table 2, we can see the average results of the PNF Stretching group's pre- and post-tests.

**Table 2**
**Comparison Of Means Of Pre-And Post-Test Scores Of Proprioceptive Neuromuscular Facilitation (Pnf) Stretching Group**

| Test | Mean | SD | t value | 2-tail prob. |
|---|---|---|---|---|
| Pre-test | 23.700 | 4.940 | 25.82* | .000 |
| Post-test | 35.400 | 5.828 | | |

* Significant at 0.05 level

t-value required at 0.05 level is 2.045 (df 29)

Table 2 shows that the PNF stretching group's post-test mean (35.400) was much greater than their pre-test mean (23.700). In comparison to the tabulated t-value (2.045) at 29 degrees of freedom and 0.05 level of confidence, the t-value (25.82) was found to be highly significant (P<.05). Thus, there is a statistically significant increase in hamstring flexibility among those who practise PNF stretching. Figure 2 clearly

displays the outcome using bar graphs.

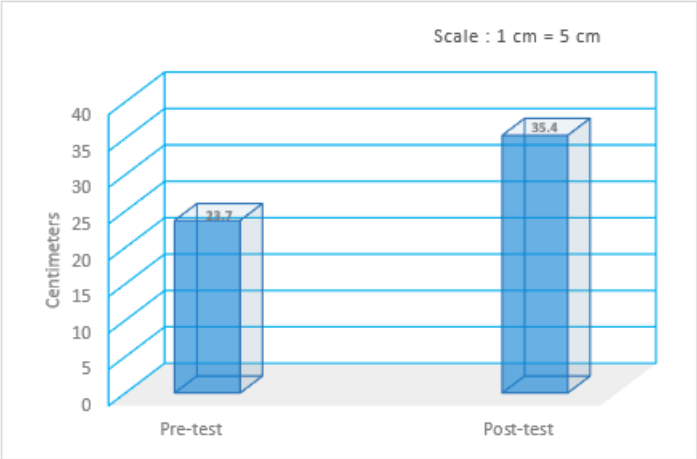


**Figure 2. Graphic Representation of Means of Pre-and Post-test scores of Proprioceptive Neuromuscular Facilitation (PNF) Stretching Group groups**

Table 3 displays the results of a comparison between the control group's mean pre- and post-test scores.

**Table 3**

**Comparison of means of pre - and post-test scores of control group**

| Test | Mean | SD | t value | 2-tail prob. |
|---|---|---|---|---|
| Pre-test | 23.700 | 2.491 | 1.37 | .184 |
| Post-test | 23.900 | 2.736 | | |

Insignificant at 0.05 level

t-value required at 0.05 level is 2.045 (df 29)

Table 3 shows that the control group's post-test mean (23.900) was not statistically different from their pre-test mean (23.700). When compared to the tabulated value of 2.045 at 29 degrees of freedom and a 0.05 level of confidence, the t-value of 1.37 was not highly significant (P>.05). Therefore, there is no statistically significant change in the control group's hamstring flexibility. In Figure 3, the result is also clearly shown using bar graphs.

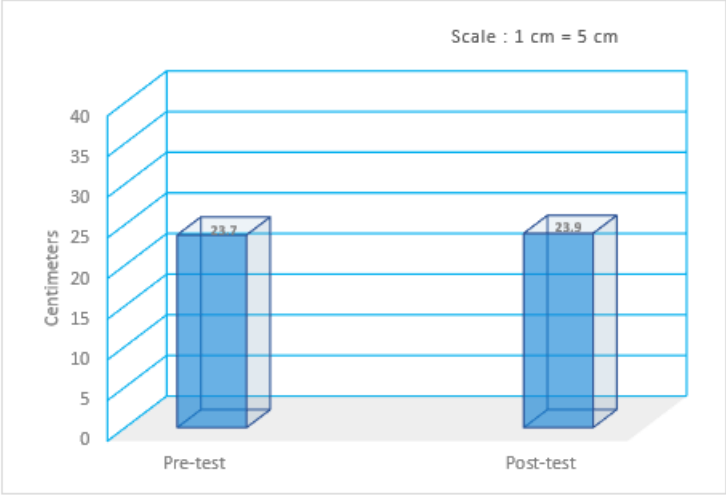


**Figure 3. Graphic Representation of Means of Pre-and Post-test Scores of Control Group**

As shown in Table 4, the analysis of variance was performed on the mean differences of the post-test scores in hamstring flexibility for the Static stretching group, the PNF stretching group, and the control group.

**Table 4**

**Analysis Of Variance Of Mean Differences Of Post-Test Scores Of Static Stretching, Pnf Stretching, And Control Groups**

| Source of Variance | df | Sum of Squares | Mean Square | F-value | 2-tail prob. |
|---|---|---|---|---|---|
| Total | 89 | 4296.1 | 1047.1 | | |
| Between groups | | 2094.2 | | 41.3724* | .000 |
| Within Groups | 87 | 2201.9 | 25.30 | | |

* Significant at 0.05 level

The limit of confidence at 0.05 level is 3.10

At a level of confidence of 0.05 and 2,87 degrees of freedom, the estimated F-value (41.3724) was found to be highly significant (P<.05) when compared to the reported F-value (3.10) in Table 4. As a result, post-training hamstring flexibility varied significantly among the three categories.

The significance of the difference between the paired means of the Static stretching, PNF stretching, and Control groups was tested using Scheffe's post-hoc test, since the F-ratio was determined to be significant. Table 5 displays the results of the data analysis.

**Table 5**

**Significance Of Difference Between The Paired Means Of Static Stretching, Pnf Stretching, And Control Groups**

| Static Stretching Group | PNF Stretching Group | Control Group | Mean Difference |
|---|---|---|---|
| 32.00 | 35.40 | | 3.4* |
| 32.00 | | 23.90 | 8.1* |
| | 35.40 | 23.90 | 11.5* |

* Significant at 0.05 level

The limit of confidence interval at 0.05 level is 3.2343.

Using a 0.05 level of confidence, the data in the table above show that the Static stretching, PNF stretching, and Control groups had significantly different post-test results. The mean scores of the static stretching are shown in Figure 4 as bar graphs. Comparing the PNF stretching group to the control group in terms of hamstring flexibility after training.

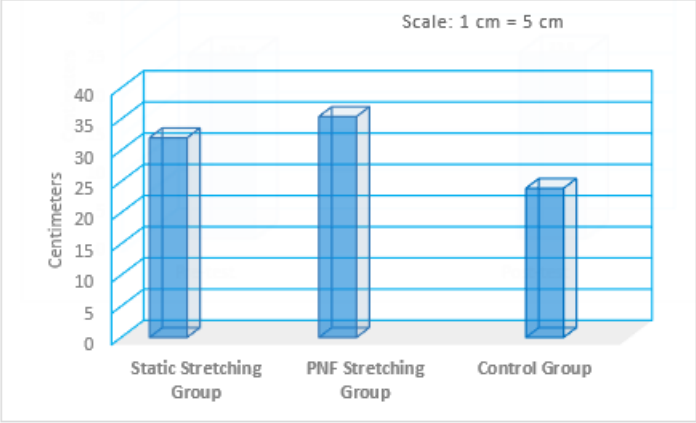


**Figure 4. Graphic Representation of Means of Post-Test Scores of Static Stretching, PNF Stretching, and Control Groups**

## DISCUSSION OF FINDINGS

Being able to bend and twist at will is a must for success in any kind of athletic endeavour. Athletes benefit from increased agility, poise, self-assurance, and flexibility. Greater stretching of the affected muscles is made possible by an increase in the range of motion. Because of this,

these muscles are able to generate greater force. Greater force may be exerted by a muscle that has been pre-stretched. Modern flexibility training often makes use of PNF stretching techniques.

According to many studies (Moor & Hutton, 1980, Prentice, 1983; Sady, Wartman, and Blanke, 1988, Tenigawa, 1973), PNF stretching techniques had the best results.[3] Strength training may also help with power balance, joint stability, endurance, circulation, and coordination. Some people who advocate for PNF stretching say that it helps people feel more passively mobile (Michael J. Alter, 1988)[4].

A number of important neurophysiological processes form the basis of PNF stretching. These include resistance, radiation, continuous induction, reflexes, facilitation, and inhibition. Efforts that raise neuronal excitability are known as facilitative actions. Another way to get the antagonist muscles to relax is to do isometric contractions with the agonist muscles. A reciprocal inhibitory reflex allows for relaxation as a result of this activity. This works by sending excitatory impulses from afferent nerves to the motor neurones supplying the muscles that are acting as an agonist, and inhibiting the neurones that are acting as an antagonist. According to Michael J. Alter (1983), it also aids in improving yield flexibility by stretching PNF.

One way to strengthen or relax muscle groups is through proprioceptive neuromuscular facilitation (PNF) techniques, which involve proprioceptive stimulation. There is a principle in PNF that says you should stretch your muscles before you voluntarily contract them. This will help you relax your muscles, which will enhance your joint range of motion and decrease the reflexive parts of your contractions. In addition to helping with agility, balance, and flexibility, this would be fantastic for both. Studying the long-term effects of varying PNF stretching intensities on hamstring flexibility, Behroz et al. and Dehghani et al. found that sub-maximal CR PNF training increased hamstring flexibility[5].

Deep stretches may be created using reflexes in PNF (Proprioceptive Neuromuscular Facilitation) stretching, which can further increase flexibility and range of motion. Consistent training, including PNF stretching into the routine many times per week, and supplementing it with other stretching methods can help sustain the flexibility improvements achieved by PNF stretching over the long run[6]. Although PNF stretching can enhance flexibility both quickly and in the long run, it takes regular practice to keep the benefits going. The key to maintaining flexibility improvements over time, according to research, is frequent stretching, which includes PNF. Strive for five times-per-week regular stretching, spending five minutes total on each muscle group each week. We may target various parts of flexibility and range of motion by combining PNF stretching with static stretching and other forms of stretching. Pay close attention to the parts of your muscles that are particularly stiff or lack flexibility; PNF may help with that. To avoid injuring ourselves by stretching too much, it is vital to pay attention to how our bodies feel and modify the amount of time and effort we devote to each stretch accordingly.

For optimal sports performance and injury prevention, it is essential to develop active and passive range of motion. PNF stretching can help with this. Athletes' leaping, throwing, and general strength can all benefit

from this, as can their muscle strength. It helps trainers and coaches focus on trouble spots by isolating and strengthening particular muscle groups. Sports performance may be enhanced with the use of PNF since it increases strength and flexibility. This can aid in injury prevention by enhancing mobility and flexibility, which in turn reduces the likelihood of harm.

People who have suffered a loss of mobility due to an accident might benefit greatly from PNF when participating in rehabilitation programs. Restoring stability and strength to damaged muscles and joints is one way it might facilitate recovery. Neuromuscular efficiency, or the capacity of the body to coordinate the movement of its muscles, can be enhanced. It can be utilised during the recovery process to target certain muscle groups that have been injured. Athletes can benefit from PNF's increased flexibility and strength during injury recovery and subsequent return to play.

## CONCLUSIONS

The following inferences are possible given the constraints of the research and the data collected:

1. One benefit of a 6-week flexibility training program for school-aged children is an increase in their hamstring muscle flexibility.
2. School-aged children can benefit from increased flexibility in their hamstrings by practicing static stretching and Proprioceptive Neuromuscular Facilitation (PNF) stretching.
3. When compared to static stretching, the Proprioceptive Neuromuscular Facilitation (PNF) method seems to be more effective in enhancing the flexibility of school-aged children's hamstring muscles.

## RECOMMENDATION

1. The study can be carried out with a substantial number of participants.
2. In order to obtain the long-term advantages, it is recommended to conduct studies with extended durations and long periods of follow-up.
3. A home stretching routine might be recommended to the subjects in addition to stretching to keep their hamstrings flexible.
4. Evaluate the results in comparison to other groups, like those who lead physically active lives.
5. Expand the number of post-test measures to include the first, second, and further months.

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