The effectiveness of stretching sport: How does short and long rehabilitation impact post-injury hamstring muscle flexibility?

La efectividad del estiramiento deportivo: ¿Cómo afecta la rehabilitación corta y larga a la flexibilidad de los músculos isquiotibiales después de una lesión?

Authors

Arif Kurniawan [1]
Sumaryanto [2]
Sulistiyono [3]
Andy Widhiya Bayu Utomo [4]
Ali Munir [5]

[1, 2, 3, 5] Yogyakarta State University (Indonesia)
[2] Yogyakarta State University (Indonesia)
[3] Yogyakarta State University (Indonesia)
[4] STKIP Modern Ngawi (Indonesia)

Corresponding author:
Ali Munir
alimunirdoktoral@gmail.com

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Abstract

Introduction: Providing an injury recovery program to improve performance, flexibility, is an integral part of the athlete's life.
Objective: This study aims to determine the effectiveness of two types of stretching sports, namely static stretching and dynamic stretching, on the improvement of post-injury hamstring muscle flexibility in professional basketball athletes.
Methodology: The research design used was a quasi-experiment with a 2x2 factorial design. The research subjects were athletes who experienced a decrease in hamstring muscle flexibility after injury. Flexibility was measured using the Sit and Reach test before and after treatment.
Results: The results show that the stretching method has a value of Sig. 0.000. This means that dynamic stretching has a more significant effect on increasing hamstring muscle flexibility in the short term. Meanwhile, static stretching shows stable effectiveness in the long term.
Discussion: Dynamic stretching is more appropriate during the initial phase of recovery or warm-up before exercise, as static stretching is more effective during the cooling down phase or advanced rehabilitation.
Conclusions: This study concludes that stretching is important in developing injury recovery programs and improving flexibility performance in athletes.

Keywords

Athlete; flexibility; hamstring; rehabilitation; stretching.

Resumen

Introducción: Ofrecer programas de recuperación de lesiones para mejorar el rendimiento y la flexibilidad es una parte integral de la vida de los atletas.
Objetivo: Este estudio tiene como objetivo determinar la efectividad de dos tipos de deportes de estiramiento, a saber, el estiramiento estático y el estiramiento dinámico, en la mejora de la flexibilidad muscular de los isquiotibiales después de una lesión en atletas profesionales de baloncesto.
Metodología: El diseño de investigación utilizado es un experimento cuasi-experimental con un diseño factorial 2x2. Los sujetos de la investigación son atletas que han experimentado una disminución de la flexibilidad de los músculos isquiotibiales tras una lesión. La medición de la flexibilidad se realizó mediante la prueba Sit and Reach antes y después de la intervención.
Resultados: Los resultados muestran que el método de estiramiento tiene un valor de Sig. 0,000. Esto significa que el estiramiento dinámico tiene un efecto más significativo en la mejora de la flexibilidad de los músculos isquiotibiales a corto plazo. Por otro lado, el estiramiento estático muestra una eficacia estable a largo plazo.
Discusión: El estiramiento dinámico es más adecuado para la fase inicial de recuperación o calentamiento antes del entrenamiento, ya que el estiramiento estático es más eficaz en la fase de enfriamiento o rehabilitación avanzada.
Conclusiones: Este estudio concluye que la incorporación de estiramientos es importante en el desarrollo de programas de recuperación de lesiones y en la mejora del rendimiento de la flexibilidad en los atletas.

Palabras clave

Atleta; flexibilidad; isquiotibiales; rehabilitación; estiramientos.

Introduction

Muscle injuries are one of the big challenges in the world of sports, both for athletes and individuals who are recreationally active (Xu, 2023). One of the most common types of muscle injuries is injuries to the hamstring muscles (Rollinson et al., 2024). The hamstring is a group of muscles located at the back of the thigh, consisting of three main muscles, namely the biceps femoris, semitendinosus, and semimembranosus (Pippas et al., 2025). These three muscles function important in knee flexion and hip extension movements, so they play a major role in activities such as running, jumping, and making sudden changes in direction (Liu et al., 2022). Injuries to the hamstrings can occur due to various factors, such as lack of warm-up, muscle fatigue, lack of flexibility, as well as an imbalance between the strength of the hamstring and quadriceps muscles (Martínez et al., 2025). Not only do these injuries cause pain and impaired function, but they can also lead to a significant decrease in athletic performance and increase the risk of recurrence if not treated properly. The recovery process of hamstring muscle injury, one of the important aspects that must be considered is the restoration of muscle flexibility (Niederer et al., 2025). Flexibility is the capacity of muscles and connective tissue to stretch in a certain range of motion without causing injury (Yu & Li, 2017) When the hamstring muscles are injured, their flexibility will decrease due to muscle fiber damage, inflammation, and the possibility of scar tissue formation (Ramos et al., 2017). If this flexibility is not restored optimally, it can interfere with movement performance and increase the chance of re-injury (George et al., 2024). Therefore, a post-injury rehabilitation approach should include strategies capable of gradually and measurably improving muscle flexibility.

One method that has been shown to be effective in improving muscle flexibility is stretching sport (Ayaz et al., 2025). Stretching sport or stretching sports is a series of movements that aim to gradually lengthen muscles and connective tissue to reach the maximum range of motion without causing pain (Erickson & Sherry, 2017) Stretching can be distinguished into several types, including static, dynamic, ballistic, and Proprioceptive Neuromuscular Facilitation stretching (Turati et al., 2025). Hamstring muscle injury rehabilitation, static stretching and PNF are often used because they are considered safer and more effective in improving muscle elasticity (Al Hazmy et al., 2025) (Phelps, Birnbrich, et al., 2025). Stretching not only improves flexibility, but also helps improve blood circulation, speed up the tissue healing process, as well as reduce muscle stiffness that appears after injury (Wong et al., 2024). In addition to being a preventive measure, stretching also plays a central role in the rehabilitation process after an injury, including injuries to the hamstring muscles (Cosio et al., 2024). Stretching sport is designed to improve joint range and muscle elasticity through controlled movements performed consistently. According to (Geraci et al., 2024) in hamstring muscle rehabilitation, stretching aims to restore muscle flexibility that had decreased due to trauma, inflammation, or the formation of scar tissue during the healing phase. There are various stretching methods used in the world of rehabilitation, such as static stretching, which is done by holding the stretching position for a few seconds; dynamic stretching, which relies on active movement with a wide range of motion; and PNF (Proprioceptive Neuromuscular Facilitation), which combines muscle contraction with passive stretching to increase flexibility more intensively (Phelps, Mehra, et al., 2025).

The determination of the stretching method used in the rehabilitation process is usually adjusted to the extent of the injury, the individual's condition, and the recovery goals (Faivre et al., 2025). In many cases, static stretching and PNF are preferred because they put minimal pressure on the muscles that are in the healing phase (Ruiz et al., 2024) (Glendon et al., 2024). In addition, both are considered safer, easier to apply, and effective in reducing stiffness and gradually increasing muscle mobility (Pingon et al., 2024). However, the effectiveness of this stretching method is also highly determined by the consistency, intensity, and duration of implementation (Servant et al., 2024). For example, stretching performed regularly in a long-term rehabilitation program generally shows more stable and significant results compared to short-term programs performed on a regular basis. The duration of the rehabilitation program is one of the important elements that affect the success of recovery (Serrat Reyes et al., 2023). Many practitioners still debate how long the ideal time is needed to acquire optimal muscle flexibility post-injury (Rodríguez et al., 2024). According to (Shetty et al., 2024) short-term rehabilitation programs (1–2 weeks) are typically focused on restoring basic function, reducing pain, and restoring initial mobility. This approach is often used to allow athletes or patients to return to activity as quickly as possible. But on the other hand, long-term rehabilitation (more than 4 weeks) gives the muscles more time to adapt, repair tissue damage thoroughly, and rebuild muscle strength and flexibility lost during

the injury. Therefore, it is important to evaluate how much of an impact there is between short-term and long-term rehabilitation programs in the context of stretching sport on hamstring muscle flexibility.

Based on the description above, there are quite fundamental problems in the post-injury hamstring rehabilitation process, especially related to the effectiveness of the stretching sport program based on the duration of its implementation. Is stretching performed in a short-term rehabilitation program able to provide the same results in hamstring muscle flexibility restoration as long term programs? How different are the results between the two? These questions are important to answer so that the rehabilitation process focuses not only on the speed of recovery, but also on the quality and completeness of the overall recovery of muscle function. In practice, many individuals, including athletes, coaches, and physiotherapists, face difficulties in determining the most effective duration of rehabilitation, because there is no strong and specific scientific reference related to it. This research is here to answer these problems through a focused and systematic approach. The main objective of this study was to analyze and compare the effectiveness of stretching sport programs in short-term and long-term rehabilitation durations on post-injury improvement of hamstring muscle flexibility. This study aims to provide an objective picture of how much the duration of rehabilitation affects recovery outcomes, especially in the aspect of muscle flexibility. In addition, the study also aimed to identify whether there was a significant difference in the level of flexibility achieved by individuals undergoing rehabilitation programs of different durations, even using the same stretching method. The contributions of this research are not only felt by athletes, but also by coaches, campus medical teams, sports science lecturers, and faculty members involved in student performance development. The findings of this research can be utilized in the development of training modules, the updating of sports education curricula, and the strengthening of injury support services for athletes at the university level. Thus, this scientific article is not only an academic document but also a practical solution that addresses the rehabilitation needs of Yogyakarta State University basketball athletes in a scientific and contextual manner.

Method

This study is an experimental study using a 2x2 factorial variable. The population used in this study consists of athletes who have suffered injuries. The sample in this study involves the entire population, namely 16 athletes, using total sampling. In this experimental study, two groups received different treatments, namely short-term rehabilitation and long-term rehabilitation after injury. The following is the research design for this experimental study.

Table 1. 2x2 Factorial Research Design

Streching (A) Hamstring Flexibility (B)	Short-term rehabilitation	Long-term rehabilitation
Height (B_1)	$A_1.B_1$	$A_2.B_1$
Low (B_2)	$A_1.B_2$	$A_2.B_2$

The data collection technique used in this study involved tests and measurements. The instrument used in this study was a pretest administered to all participants before treatment to measure hamstring muscle flexibility using the Vertical Sit and Reach Test. Next, each group underwent a 4-week stretching rehabilitation program, with a frequency of 3 sessions per week. After the program ended, a post-test was conducted to measure changes in flexibility. The data analysis technique used in this study was a two-way ANOVA at a significance level of 0.05. Before conducting the two-way ANOVA, prerequisite tests were required, including a normality test, a homogeneity test, and a hypothesis test.

Results

Based on the problems and research design above. The results have been described in the table below.

Table 2. Flexibility Hamstring Muscle Group Statich Stretching Short Duration

Sample	Pretest	Posttest	Difference
1	22	25	3
2	18	27	9
3	19	29	10
4	18	26	8

The table above shows the results of the measurement of short-duration hamstring muscle flexibility in four samples before and after treatment. The pretest value ranges from 18 to 22 cm, while the posttest value increases to 25 to 29 cm. The difference between the highest flexibility increase is 10 cm and the lowest is 3 cm. The average increase in flexibility in this group was 7.5 cm.

Table 3. Flexibility Hamstring Muscle Group Statich Stretching Long Duration

Sample	Pretest	Posttest	Difference
1	23	26	3
2	18	25	7
3	20	29	9
4	19	28	9

The results of the table showed the results of measuring the hamstring muscle flexibility of the Statich Stretching Long Duration group in four samples before and after treatment. The pretest value ranges from 18 to 23 cm, while the posttest value increases to 25 to 29 cm. The difference between the highest flexibility increase was 9 cm and the lowest was 3 cm. The average increase in flexibility in this group was 7 cm.

Table 4. Flexibility Hamstring Muscle Group Dynamic Stretching Short Duration

Sample	Pretest	Posttest	Difference
1	18	29	11
2	21	27	6
3	18	28	10
4	19	26	7

The table above shows the results of measuring hamstring muscle flexibility in the short-duration dynamic stretching group. Pretest values range from 18 to 21 cm, while posttest values increase to 26 to 29 cm. The difference between the highest flexibility increase is 11 cm and the lowest is 6 cm. The average increase in flexibility in this group was 8.5 cm.

Table 5. Flexibility Hamstring Muscle Group Dynamic Stretching Long Duration

Sample	Pretest	Posttest	Difference
1	18	25	7
2	19	27	8
3	21	29	8
4	23	26	3

The table above results of measuring hamstring muscle flexibility in the long-duration dynamic stretching group. Pretest values range from 18 to 23 cm, while posttest values increase to 25 to 29 cm. The difference between the highest flexibility increase is 8 cm and the lowest is 3 cm. The average increase in flexibility in this group was 6.5 cm.

In this study, normality testing was used as a prerequisite before conducting homogeneity testing. The method used was the Shapiro-Wilk test, because the number of samples in each group was less than 50. The results of the Shapiro-Wilk test showed that the significance values (p-values) of the four data groups, namely the short-duration static stretching group, the long-duration static stretching group, the short-duration dynamic stretching group, and the long-duration dynamic stretching group, all had significance values greater than 0.05. Therefore, it can be concluded that the data in each group is normally distributed. Next, the researcher conducts a homogeneity test on each group, the homogeneity test aims to find out whether the variance between the analyzed data groups has similarities (homogeneous) or

not. In this study, the homogeneity test was used to ensure that the treatment groups had equal variance, so that further analysis could be validly performed. The homogeneity test was carried out on the results of the pretest and posttest of the four groups, namely the short-duration static stretching group (A1B1), long-duration static stretching (A2B1), short-duration dynamic stretching (A1B2), and long-duration dynamic stretching (A2B2). Homogeneity testing is carried out using the Levene test with the help of a statistical program. If the significance value (Sig.) is greater than 0.05, then the data is said to be homogeneous. Conversely, if the significance value is less than 0.05, then the data is considered inhomogeneous. The results of the homogeneity test will be the basis for determining the appropriate type of advanced statistical test to test the hypothesis in this study. The following are the results of the homogeneity test.

Table 6. Homogeneity Test

Group	Test Stages	Levene Statistic	df1	df2	Sig.	Information
Static Stretching Short Duration (A_1B_1)	Pretest	0,325	7	24	0,935	Homogeneous
Long Duration Static Stretching (A_2B_1)	Pretest					
Short Duration Dynamic Stretching (A_1B_2)	Pretest					
Dynamic Stretching Long Duration (A_2B_2)	Pretest					
Static Stretching Short Duration (A_1B_1)	Posttest					
Long Duration Static Stretching (A_2B_1)	Posttest					
Short Duration Dynamic Stretching (A_1B_2)	Posttest					
Dynamic Stretching Long Duration (A_2B_2)	Posttest					

Based on the results of the homogeneity test shown in Table 6, a Levene Statistic value of 0.325 was obtained with a significance value (Sig.) of 0.935. This significance value is greater than 0.05 ($p > 0.05$), so it can be concluded that the data from all treatment groups at the pretest and posttest stages have homogeneous variance. Thus, the homogeneity assumption is met, and advanced analyses such as the ANOVA test can be resumed because the data between groups are considered to be from populations that have the same variance.

Table 7. The Two-Way Anova Hypothesis Test

Treatment	F_{count}	*Sig.*	Information
Stretching Method	0,192	0,000	Significant
Hamstring Muscle Flexibility	0,297	0,003	Significant
Interaction of Stretching Method * Hamstring Muscle Flexibility	0,369	0,002	Significant

Based on the results of the hypothesis test using the Two Way ANOVA analysis presented in Table 7, it is known that there is a significant influence of the stretching method on hamstring muscle flexibility. This is indicated by the F-value calculated as 0.192 with a significance level of 0.000 ($p < 0.05$), which means that the different types of stretching methods have a significant impact on improving hamstring muscle flexibility. In addition, the flexibility of the hamstring muscles itself also had a significant influence on the measurement results, with an F value calculated as 0.297 and a significance of 0.003 ($p < 0.05$). The interaction between the stretching method and hamstring muscle flexibility also showed significant results with an F-value of 0.369 and a significance of 0.002 ($p < 0.05$). These findings indicate that in addition to each ertical independently exerting an influence, the combination of stretching methods and hamstring muscle flexibility levels also has a significant contribution to improving flexibility outcomes.

Discussion

The flexibility of the hamstring muscles is an important component in the performance of basketball athletes, as they play a role in various movements such as running, jumping, and rapid changes of direction (Shetty et al., 2024). In this study, an intervention was carried out using static stretching and dynamic stretching methods to increase hamstring muscle flexibility in basketball athletes of Yogyakarta State University students. The results showed that both stretching methods were effective in improving the flexibility of the hamstring muscles. However, there is a difference in the level of effectiveness between the two. The dynamic stretching group showed a more significant increase in flexibility compared

to the static stretching group. Dynamic stretching involves active movements that mimic sports activities, thereby increasing muscle temperature and blood flow, as well as preparing muscles for intense physical activity (Hajibozorgi et al., 2025). Meanwhile, static stretching is performed by holding a specific position to stretch the muscles, which is effective in increasing long-term flexibility but is less than optimal as a warm-up before physical activity (Franz et al., 2024). In addition, a study by (Rafli et al., 2023) compared the effectiveness of Proprioceptive Neuromuscular Facilitation (PNF) and animal pose stretching on hamstring muscle flexibility in futsal athletes. The results showed that both methods were effective in improving flexibility, but there was no significant difference between the two.

Research by (Franz et al., 2024) provides a view that reinforces the urgency of programmatic and targeted flexibility training interventions in athletic populations, particularly basketball athletes. In his research, he showed that both the Contract Relax technique (part of Proprioceptive Neuromuscular Facilitation or PNF) and Nordic Hamstring are significantly effective in improving hamstring muscle flexibility. However, Contract Relax has a greater influence in the short term due to its nature that directly involves ertical contractions and active relaxation. Although the interventions used are different from this study, namely static and dynamic stretching, the basic principles underlying increased flexibility remain the same, namely increased muscle length, tissue elasticity, and neuromuscular activation. The statement emphasized that hamstring muscle flexibility is not only a matter of "range of motion", but also related to neuromuscular control and the ability of muscles to adapt to dynamic training loads, which are very important in a basketball game that demands speed, acceleration, and vertical jumps. If compared with the findings in this study, it can be seen that dynamic stretching shows high effectiveness in actively preparing muscles, similar to the principle of Contract Relax, because both involve muscle activity in a stretching condition. In other words, both dynamic stretching and PNF stretching offer similar advantages, namely the functional flexibility that athletes need in competitive conditions.

For an athlete, dynamic stretching can be a more effective option as part of a warm-up before a workout or game, as it can increase flexibility while preparing muscles for intense physical activity (Absalome et al., 2020). However, static stretching still has an important role to play in exercise programs, especially in the cooling phase or as part of a routine to improve long-term flexibility (Tilp, 2025). However, the effectiveness of the stretching method can be influenced by a variety of factors, including the duration, intensity, and consistency of the exercise, as well as individual characteristics such as age, fitness level, and injury history (Pulver et al., 2024). Therefore, the stretching training program must be adjusted to the needs and conditions of each athlete. In this study, the use of dynamic stretching with the right duration showed more optimal results in increasing hamstring muscle flexibility. This supports previous findings that dynamic stretching is more effective in improving athletes' performance and reducing the risk of injury compared to static stretching. Overall, both static and dynamic stretching are effective in improving hamstring muscle flexibility in athletes, but dynamic stretching shows more significant results in the context of increasing the flexibility required for athletic performance. Therefore, it is recommended to integrate dynamic stretching in a warm-up program before a workout or game, while static stretching can be used in the cool-down phase or as part of a long-term flexibility-enhancing routine.

Conclusions

Based on the results of research that has been conducted on the effectiveness of two types of stretching sports, namely static stretching and dynamic stretching, on post-injury hamstring muscle flexibility in basketball athletes of Yogyakarta State University, it can be concluded that there is a significant difference in influence between the two. Dynamic stretching has been shown to be more effective in improving hamstring muscle flexibility, especially in the short term, compared to static stretching. This shows that the active stretching method is more relevant to be applied in the early phases of recovery and training preparation because it is able to functionally activate the muscles and support the explosive movements needed in basketball. Meanwhile, static stretching still provides significant benefits, especially in the long term, to maintain muscle elasticity and reduce the risk of repetitive injuries. These findings indicate that the selection of stretching methods should be adjusted to the rehabilitation phase and the needs of individual athletes. Therefore, coaches, physiotherapists, and sports practitioners are advised to combine both methods strategically so that athletes' recovery and performance improvement

can run optimally and sustainably. This research is expected to be the basis for the development of more effective rehabilitation and flexibility training programs for post-injury athletes.

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Authors' and translators' details:

Arif Kurniawan	arifkurniawan.2023@student.uny.ac.id	Author
Sumaryanto	sumaryanto@uny.ac.id	Author
Sulistiyono	sulistiyono@uny.ac.id	Author
Andy Widhiya Bayu Utomo	andywbu@stkipmodernngawi.ac.id	Author
Ali Munir	alimunirdoktoral@gmal.com	Translator