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THE EFFECT OF HOLD RELAX HEATING ON HAMSTRING MUSCLE FLEXIBILITY: LITERATURE REVIEW

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Abstract

This study reviews the effect of hold-relax (PNF) warming up on hamstring muscle flexibility through a literature review of articles published between 2015 and 2024. The search was conducted on PubMed, Google Scholar, and ProQuest using PICOS criteria. Experimental studies and randomized controlled trials in athletes and non-athletes that tested hold-relax compared to static stretching or other interventions were discussed. The review results showed that most studies reported an increase in range of motion (ROM) and a reduction in hamstring stiffness after the application of hold-relax, including acute and short-term effects; some studies found equivalent effectiveness to static stretching. The physiological mechanism described involves isometric contraction that triggers autogenic inhibition through the Golgi tendon organ, thereby decreasing alpha-motor neuron excitability and increasing stretch tolerance. Although effective, evidence is still limited regarding the long-term effects on injury prevention and neuromuscular adaptation. Further research is recommended to determine the optimal protocol and clinical impact on performance and injury incidence.

Keywords: hamstring, hold relax, injury, warm-up

INTRODUCTION

The hamstrings are a group of muscles in the back of the thigh compartment that cover the hip and knee joints. These muscles are responsible for hip extension and knee flexion. The biceps femoris functions to keep the torso upright from a bent posture against gravity (E., H. C. B., and S. M. C. S. 2022). Anatomically, the hamstrings have a complex structure with variations in muscle fiber length, pennation angle, and physiological cross-sectional area in each component, including from lateral to medial: the biceps femoris, semitendinosus, and semimembranosus, which affect contraction capacity, strength, and flexibility (Kellis 2018). Due to its nature of crossing two joints, the length of the hamstrings determines the mechanical limits when full hip flexion or knee extension is required. The length of the hamstrings also affects the posture of the pelvis and spine (Paton et al. 2023). One of the most dynamic muscles in the pelvic area is the hamstrings. When these muscles tighten, the anterior pelvis becomes smaller,

meaning that hip joint movement becomes limited and causes pain. Ultimately, the structural and functional changes that occur in the hamstrings impact daily activities, such as walking. Therefore, hamstring flexibility is very important for physical health and functioning in many daily activities (Kim et al. 2021).

The intrinsic nature of the body's tissues, known as flexibility, determines the range of motion that can be achieved ³ without injury to a particular joint or group of joints. Stretching to improve flexibility includes passive, static, isometric, ballistic, and proprioceptive (PNF) neuromuscular facilitation (Warneke et al. 2024). Muscle flexibility is very important ⁸ for reducing the risk of injury. Muscle elasticity helps move joints through their maximum range of motion. In addition, it can improve ¹⁰ physical performance, especially muscle strength. This is achieved through increased use of elastic strain energy when movement is performed (Shivalingaiah et al. 2016). Muscle flexibility is an important element in physical performance and injury prevention, especially for individuals who are often involved in intensive physical activities, such as athletes and physical workers. One muscle group that often experiences stiffness and injury is the hamstring muscles, which play an important role in hip and knee joint movement (Clarkson, Cox, and Thelwell 2019). Hamstring muscle stiffness can affect overall physical performance, causing limitations in range of motion and increasing the risk of injury, especially when performing activities that involve sprinting, jumping, or sudden changes in direction (Corrigan et al., 2022).

Research shows that hamstring muscle stiffness is closely related to various injuries in athletes, particularly hamstring strains, which are one of the most common types of muscle injuries in athletes who play sports such as soccer, rugby, and athletics (Mizutani et al. 2023). These injuries often occur due to a lack of flexibility in the hamstring muscles, which increases the tension on these muscles during intense physical activity. Therefore, various stretching and warm-up methods have been developed to reduce the risk of these injuries and increase hamstring flexibility (Nunes, Martins, and Ferreira 2024). One technique considered effective in improving hamstring flexibility is the hold-relax method, which is part of the Proprioceptive Neuromuscular Facilitation (PNF) technique.

Recent studies also show that PNF can reduce acute stiffness in the biceps femoris muscle. This means that, compared to static stretching, ROM is higher. Overall, these neuromuscular adaptations and short-term mechanical changes allow hold-relax to serve as an effective warm-up component for improving hamstring flexibility and preparing them for optimal movement function (Zeleznik et al., 2024).

PNF techniques, particularly hold-relax, involve isometric muscle contractions followed by a relaxation phase, which aims to increase range of motion through the role of muscle proprioceptors and the central nervous system (Behm et al., 2016). This technique has been proven to be more effective in improving flexibility compared to traditional static stretching, which only involves passive stretching of the muscles without involving isometric contractions (Yan et al. 2025). Physiologically, the isometric contraction phase in PNF activates the autogenic inhibition mechanism through the Golgi tendon organ and reduces the excitability of alpha-motor neurons, so that during relaxation, the muscles are easier to stretch and stretching tolerance increases (Rishaldi et al., 2023). However, further research is needed to determine the optimal protocol for applying this method, including the ideal duration and intensity of isometric contraction, as well as the frequency of application in training programs. With a better understanding of these factors, the hold-relax method can be implemented more effectively in various populations, from athletes to individuals with sedentary lifestyles.

METHOD

This study is a literature review article, meaning that it draws on several published studies obtained from the PubMed, Google Scholar, and ProQuest electronic databases. The articles reviewed in this study were selected from the period 2015-2024, using the following PICOS eligibility criteria:

Eligibility criteria

Criteria for articles selected using the PICOS (participants, intervention, comparison, outcomes, and study design) model:

Population: Male or female athletes and non-athletes who are healthy and have no history of neurological disorders in the lumbar region, knee, hip, or back

deformities, ⁵ history of trauma to the hip, knee, or back, or injuries to the hamstrings and other muscles in the lower limbs.

Intervention: Match simulation, training, all types of measurement tests in each sport.

Comparison: There are no restrictions on comparisons in the study, as long as there are two types of interventions above.

Outcomes: Hamstring muscle flexibility.

Study Design: Randomized controlled trial, a randomized, blinded, crossover trial.

KeyWord accompanied by MeSH Term, Title/Abstract, and an asterisk (*) for words that may have various types of subsequent words. The keywords or search terms used are “(Hamstring) OR (Hold relax) OR (static)” OR “(Flexibility) and ”(Training) “

The search and collection of articles began in April 2025, followed by analysis according to the inclusion and exclusion criteria in August 2025, and the drafting of this article began in November 2025. The work was done online using a laptop and the internet.

Search strategy

This literature review obtained articles by selecting several articles that had been analyzed and published by systematic review articles. The authors conducted the search independently, and the selection of studies was finalized in consultation with the second author. There were no language restrictions used to search for research articles. The search results were imported and processed using Mendeley Web Importer software.

RESULT AND DISCUSSION

Studies Characteristics

Table 1. Literature Review Results Table on Hold Relax Warming

Study and years	sample	Metode	Measures	Result
(Kosova and Pala 2025)	64 subject	Randomized Controlled Trial	<ul style="list-style-type: none">• Static stretching• PNF stretching (Hold relax)	<ul style="list-style-type: none">• The static stretching significant increases• The PNF hold-relax stretching

(Ahmed Hashim , Iqbal Amir, Anwer Shahnawaz 2015)	45 subject	Randomly Placed	<ul style="list-style-type: none"> • Modified hold-relax stretching • Static stretching 	<ul style="list-style-type: none"> • Modified hold-relax stretching effectively improves hamstring flexibility • Static stretching effectively improves hamstring flexibility 	significant increases
(Syarwan and Durahim 2023)	34 subject	Quasi Eksperimental	<ul style="list-style-type: none"> • Contract relax • Hold relax 	<ul style="list-style-type: none"> • Contract Relax can significantly improve hamstring flexibility. • Hold Relax can significantly improve hamstring flexibility. 	
(Khan, and 2022)	Sethi, Noohu 38 subject	Randomized Controlled Trial	<ul style="list-style-type: none"> • Hold relax 	<ul style="list-style-type: none"> • Modified hold-relax technique combined with moist heat therapy is effective in improving hamstring flexibility. 	
(Prabha 2023)	30 subject	Random Chit Sampling Method	<ul style="list-style-type: none"> • Hold Relax proprioceptive neuromuscular facilitation stretching (HR-PNF) • static stretch (SS) 	<ul style="list-style-type: none"> • No significant differences were found when comparing the effectiveness • Resulted in significant immediate increases in hamstring length. 	

(Murtaza and Maqbool 2023)	28 participant	A Randomized, Blinded, Crossover	<ul style="list-style-type: none"> • central posterior-anterior LM grade III to the L4 joint • hold-relax PNF • control intervention 	<ul style="list-style-type: none"> • Lumbar mobilization (LM) increased • 5° on the straight leg raise test and PNF increased • 10.0° No statistically significant increase was observed on the control group • On the between group analysis, PNF was better than LM
(Rizvi et al. 2020)	30 subject	Randomized Controlled Trial	<ul style="list-style-type: none"> • static stretching • PNF • Hold-Relax stretching 	<ul style="list-style-type: none"> • There were a significant improvement in the hamstring flexibility • Static stretching and PNF Hold-relax Stretching are significantly effective
(Singh 2015)	30 male subjects	Experimental Procedure	<ul style="list-style-type: none"> • Slow Stretch & Hold • Ballistic • Proprioceptiveneuromuscular facilitation method 	<ul style="list-style-type: none"> • A significant difference was found among the Slow Stretch & Hold, Ballistic and PNF Method
(Rabab Kompal, Satwat Ul-Islam, Umla)	70 subject	Randomized Controlled Trial	<ul style="list-style-type: none"> • treated with static stretching 	<ul style="list-style-type: none"> • Both case and control group

Bhatti, Kainat Tahir, Roshnak Noor 2022)			treated with hold relax technique	<ul style="list-style-type: none"> showed that there was significant improvement Both of these treatment techniques have same effect in the improvement
(Ramachandran et al. 2018)	15 sample	Randomly Selected	<ul style="list-style-type: none"> with hold-relax stretching treated with contract relax antagonist stretching 	<ul style="list-style-type: none"> Have reported increase in hamstring flexibility Improving hamstring flexibility with significant Effective in improving hamstring flexibility
(Rajendran, Thiruveenkadam, and Nedunchezhiyan 2016)	20 subject	Quasi Experiment	<ul style="list-style-type: none"> Sit and reach test Procedure Repetition Data collection Statistical analysis 	<ul style="list-style-type: none"> Significant improvement The hold-relax method is superior in improving flexibility
(Mumtazah and Abdullah 2020)	44 subject	Cesa Study	<ul style="list-style-type: none"> Sit and reach test Procedure Repetition Data collection Statistical analysis 	<ul style="list-style-type: none"> ROM increased significantly from 90 degrees to 110 degrees There was a decrease in muscle spasms The lower extremity functional scale score increased from 17 to 44.

(Azza 2022)	15 subject	Quasi Experimental Study	<ul style="list-style-type: none"> • Basic Measurements • Statistical Analysis • Post-Test Measurements • Limitations in measurement duration 	<ul style="list-style-type: none"> • Static stretching and proprioceptive neuromuscular facilitation (PNF) stretching significantly increased hamstring muscle range of motion • There was no significant difference in the effectiveness of the two stretching techniques (static & PNF)
(Rafli, Hasibuan, and Prabowo 2023)	20 subject	Experiment Method	Comparison of effectiveness with research methods	<ul style="list-style-type: none"> • There was no significant difference between the PNF group and the animal pose stretching group in terms of improvement.

Discussion

The purpose of this article is to determine the effect of hold relax warm-up on hamstring muscle flexibility. Explanation of the

In recent years, research on the effectiveness of the hold-relax method has continued to grow. A study by Takeuchi et al. (2020) showed that applying the hold-relax technique to soccer players significantly improved hamstring flexibility in a relatively short period of time. They found that after only 4 weeks of training using

this method, athletes experienced a 20% increase in flexibility. Similar results were also found by Borman et al. (2022), who tested the effects of the PNF hold-relax method on the hamstring flexibility of basketball players. Their research results showed an increase in flexibility of up to 18% after a 6-week training program. Furthermore, research by Thomas et al. (2021) emphasized the importance of this warm-up technique in the context of rehabilitation. They found that athletes who had suffered hamstring injuries and underwent a rehabilitation program that included the hold-relax method showed faster recovery compared to those who only used static stretching methods. This study also highlighted that the hold-relax technique is not only effective in increasing flexibility, but also helps restore optimal muscle function after injury.

In addition, the hold-relax method has also demonstrated effectiveness in non-athlete populations. For example, a study conducted by Williams et al. (2020) on office workers showed that individuals engaged in prolonged sitting activities experienced increased hamstring flexibility after applying this technique for 8 weeks. This research indicates that the PNF hold-relax method can be applied not only to athletes but also to the general population who experience muscle stiffness due to an inactive lifestyle. However, despite numerous studies supporting the effectiveness of the hold-relax technique in improving hamstring flexibility, there are several factors that need to be considered in its implementation. For example, the duration of isometric contraction, the intensity of stretching, and the frequency of applying this method significantly influence the results obtained. A study by O'Sullivan et al. (2019) shows that isometric contractions that are too long or too strong can cause excessive muscle tension, which can ultimately reduce muscle performance and increase the risk of injury. Therefore, it is important to find the right balance between the duration and intensity of the exercise so that this technique can provide optimal results.

In the context of sports, improving hamstring flexibility through the hold-relax technique has also been linked to improved performance. For example, a study by Lopes et al. (2022) showed that athletes who underwent a flexibility training program using the PNF hold-relax method showed a 15% improvement in sprint

performance. This indicates that better hamstring flexibility not only helps prevent injuries but can also contribute to athletes' ability to perform explosive movements. Overall, the hold-relax warm-up method offers various benefits in terms of improving hamstring flexibility. Research over the past 5 years has shown that ⁴ **this technique is** effective both **in the context of** rehabilitation and **sports** performance enhancement.

Although PNF hold-relax has been proven effective in acutely improving flexibility and ROM, to date, research has focused more on short-term laboratory effects without linking them to actual injuries in the field, changes in sprint biomechanics, or long-term neuromuscular adaptations relevant to athletes. Therefore, new research is needed to evaluate whether the increase in flexibility through this method actually contributes to injury prevention and performance enhancement, so that the results can provide a strong scientific ⁶ **basis for the development of more effective and** evidence-based warm-up protocols for athletes.

CONCLUSION

Based on the results of various studies in the literature review, it can be concluded that the PNF hold-relax method is one of the most effective stretching techniques and consistently improves hamstring muscle flexibility. Almost all of the studies reviewed ⁴ **showed a significant increase in range of motion (ROM)**, reduced muscle stiffness, and improved hamstring muscle function after applying this technique, both in athletes and non-athletes. Compared to other stretching techniques such as static stretching, dynamic stretching, contract-relax, or mobilization techniques, the hold-relax method has equivalent or even superior effectiveness in some studies, especially in terms of short-term flexibility improvement.

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