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# The effects of static and dynamic stretching exercises on the lower extremity performance

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## Abstract

The research study aimed to investigate the effects of static and dynamic stretching exercises on lower extremity performance. The study involved a sample of participants divided into two groups: five in the static stretching group and five in the dynamic stretching group. Specifically, the research aimed to (1) determine the mean lower extremity performance (vertical jump height) of the participants before and after the intervention of static and dynamic stretching; (2) identify the significant difference between the pre-test and post-test outcomes of lower extremity performance when static stretching is applied; and (3) identify the significant difference between the pre-test and post-test outcomes of lower extremity performance when dynamic stretching is applied. Participants performed specific stretching routines before engaging in lower extremity exercises, and measurements of maximum performance—including strength, power, and flexibility—were recorded before and after the interventions. The results were analyzed to assess the impact of both stretching types on lower extremity performance. Static stretching showed positive effects on strength, power, and flexibility, which can enhance overall performance. In contrast, the findings suggest that dynamic stretching may negatively impact lower extremity performance when performed before activities that require explosive movements or high-intensity efforts. Therefore, it is advisable to limit the use of dynamic stretching in pre-exercise routines and instead incorporate it into post-exercise or cooldown sessions.

**Keywords:** *lower extremity (LE), exercise, static stretching (SS), dynamic stretching (DS)*

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## 1. Introduction

Stretching is often performed intentionally after waking up, following prolonged inactivity, or upon exiting cramped environments. While stretching offers numerous benefits (Afonso et al., 2021; Page, 2012; Warneke et al., 2025; Zvetkova et al., 2023; Bouguezzi et al., 2023; Afonso et al., 2024; Chaabene et al., 2019), incorrect technique can lead to negative consequences such as hypermobility, instability, or even permanent damage to tendons, ligaments, and muscle fibers (Behm et al., 2016; Allen et al., 2005). Different stretching methods vary in their efficacy and safety depending on the muscle groups involved (Behm et al., 2023; Mehraban et al., 2024; Rosenfeldt et al., 2024; Cai et al., 2023). According to Matsuo et al. (2019), stretching is an excellent method to maintain flexibility and alleviate everyday stress, and incorporating stretching into leisure time, such as while watching TV, can be an effective way to improve mobility. Stretching before physical activity serves primarily as a preparatory warm-up, not solely to increase flexibility (Herbert & Gabriel, 2002).

Aerobic exercises remain the most common warm-up, but static and dynamic stretching have become integral due to their distinct effects on muscle function (Warneke et al., 2024; Faelli et al., 2021; Donti & Bogdanis, 2025; Arntz et al., 2024). Alp and Kurt (2018) recommend field-appropriate static and dynamic stretching to maintain strength and stability, crucial for physical fitness. Evidence suggests dynamic stretching generally improves muscle performance more than static stretching during warm-up (Esteban-García et al., 2024; Behm & Chaouachi, 2011; Samson et al., 2012; Daneshjoo et al., 2024; Jaggers et al., 2008), though consensus is lacking. For example, Behm et al. (2023) found minimal difference between static and dynamic stretching in flexibility tests, whereas Konrad et al. (2024) demonstrated that dynamic stretching yields superior improvements in flexibility among adolescents. Moreover, Hody et al. (2019) reported that dynamic stretching reduces muscle stiffness less than static stretching, an important consideration given the association between elevated stiffness and muscle injury risk.

Pre-exercise stretching offers benefits such as injury risk reduction and enhanced athletic performance. However, studies challenge the effectiveness of static stretching immediately before exercise due to its potential to decrease muscle force output and alter stiffness negatively (Kay & Blazevich, 2012). A thorough understanding of the acute effects of static versus dynamic stretching on muscle properties is essential to recommend optimal warm-up protocols. Although static stretching has traditionally been included to prevent injuries, Pallarés et al. (2021) highlighted its possible detrimental effects on performance, which has led practitioners to favor dynamic stretching and more comprehensive warm-up routines.

This evolution in warm-up practices is especially critical in sports requiring rapid, multidirectional movements such as soccer, where abrupt acceleration, deceleration, and frequent direction changes are common (Sliwowski, 2021; D'Onofrio et al., 2024). For student-athletes balancing academic demands and sport, efficient and injury-preventative warm-up strategies are vital. Many have histories of injury, making safe, non-intensive performance enhancement methods imperative. This research thus benefits student-athletes recovering from injury and recreational players who lack access to gyms or intensive training programs but wish to improve lower extremity performance safely (Page, 2012).

This study tested the following hypotheses:

HO1: There is no significant difference on the pre-test and post-test outcome in terms of lower extremity performance when static stretching is done.

HO2: There is no significant difference on the pre-test and post-test outcome in terms of lower extremity performance when dynamic stretching is done

## 2. Literature Review

Many athletes incorporate stretching before exercise as an essential part of their warm-up routine to maximize athletic performance and prepare their bodies for practice or competition. Stretching protocols in physical education and sports have been extensively studied (i.e. Babault et al., 2021; McHugh & Cosgrave, 2009; Knudson, 2025) however, discrepancies and conflicting results remain common due to variations in methodologies and testing procedures, making comparisons across studies challenging (Gerdijan et al., 2021). Static stretching, which involves moving a limb to the end of its range of motion and holding it, has been a traditional component of warm-ups for decades. While dynamic stretching has gained popularity for its positive pre-performance effects, some studies have found that static stretching does not necessarily impair performance (Young, 2007; Young & Behm, 2002, as cited by Gerdijan et al., 2021; Handrakis et al., 2010; Loughran et al., 2017).

Wakefield and Cottrell (2015) investigated the impact of static hip flexor stretching on vertical jump height and observed a 1.74% decrease in vertical jump height following static stretching of the hip extensors but a 1.74% increase after hip flexor stretching. Although the effects of antagonist static stretching on jump performance are documented, research on the influence of antagonist static and dynamic stretching on agonist muscle strength performance remains limited (Serefoglu et al., 2017).

Full range of motion (ROM) resistance training has been demonstrated to be more effective than partial ROM for optimizing muscle strength and lower-limb hypertrophy, as well as improving functional performance. Nevertheless, no significant differences have been found between full and partial ROM training regarding changes in muscle architecture (Freitas et al., 2022). Regarding stretching and performance, dynamic stretching has been widely supported for its benefits on increasing joint ROM and enhancing muscular performance. These improvements are primarily attributed to decreased stiffness of the muscle-tendon unit and increased muscle temperature and potentiation induced by voluntary contractions during dynamic movements (Opplert & Babault, 2018). Consequently, dynamic stretching is often recommended as a preferable warm-up method over static stretching when the goal is to improve joint mobility and muscle force or power output.

Few studies have explored how stretching antagonist muscles influences agonist muscle function. Sandberg et al. (2012) found that static stretching of hamstrings may increase isokinetic quadriceps torque at high angular velocities, while static stretching of hip flexors and ankle dorsiflexors can enhance vertical jump height and power (Wakefield & Cottrell, 2015; Sandberg et al., 2012). Such findings suggest that targeted antagonist stretching could be strategically employed to improve performance, though further research is warranted to clarify these effects fully.

To guide stretching recommendations, the American College of Sports Medicine (ACSM, 2013) convened an expert panel that analyzed available evidence and concluded that healthy individuals should perform stretching exercises for all major muscle-tendon groups at least two to three times per week, with daily stretching being most effective. Each stretching exercise should be held for a total of 60 seconds, with repetitions adjusted according to the individual’s tolerance, three repetitions if they can hold for 15 seconds, or two repetitions if they can hold for 20 seconds. This protocol aims to optimize flexibility and musculoskeletal health.

The vertical jump test is one of the most prevalent assessments in sports performance evaluation. Despite its widespread use, Santos et al. (2022) highlighted that an overemphasis on vertical jump monitoring can paradoxically reduce training quality and decision-making effectiveness in team settings. Nonetheless, vertical jump training remains a highly effective method to develop explosive leg strength, power, balance, and coordination—qualities essential across many sports. Endurance athletes, particularly runners, frequently employ dynamic stretching as part of their injury prevention strategies, given their relatively lower risk for muscle strains compared to athletes in high-impact, sprinting-based sports. For these athletes, dynamic stretching acts as a supplemental protective mechanism.

An economical and practical method to measure vertical jump height involves the use of tape or chalk. As described by Schunzel (2021), the athlete marks the highest reachable point on a wall with tape or chalk while standing beside it, then measures the distance from the ground to the mark using a tape measure. This simple technique enables consistent and accessible performance assessment.

Selecting the appropriate type of stretching before and after physical activity is crucial for athletes to maximize performance and reduce injury risk. Despite the acknowledged importance, stretching is often neglected outside of elite athletic populations due to insufficient awareness of its benefits. Existing studies suggest that stretching can increase muscle force and joint range of motion. Specifically, hamstring stretching can enhance isokinetic quadriceps torque, while stretching of hip flexors and ankle dorsiflexors may improve vertical jump height and power.

Overall, possessing strong and functional lower extremities is fundamental for athletes across sports disciplines. This study aims to examine whether static or dynamic stretching more effectively improves lower extremity performance, providing insights to optimize warm-up routines for diverse athletic populations.

## 3. Methodology

The study followed an experimental type of research. The participants in the experimental group were exposed to the intervention. The independent variable in this study was the type of stretching, static and dynamic, while the dependent variable was the performance of the lower extremities. The experimental group, which was divided into two, performed static and dynamic stretching exercises daily for two weeks, with a minimum frequency of three times per week (ACSM, 2021). The first group performed static stretching for 30 seconds per leg (Master, 2021).

*Long Lunges*. Participants started with one foot out in front while kneeling. The opposite leg was placed behind, kept straight with the knee touching the floor.

*Pigeon Pose*. After lunging, the right leg was placed in front. The right foot was moved toward the left thigh as close as possible, within the pain threshold.

*Hamstring Stretch*. While seated, both legs were extended in front of the torso. Participants held onto their toes and gently leaned forward while keeping the chest upright.

*Butterfly Stretch*. Seated with soles of the feet together, participants leaned forward softly while maintaining a straight upper body.

*Straddle*. While standing, participants spread their feet wide with toes pointing forward. Their hands rested on the ground, and the chest remained straight.

*Middle Splits*. Participants assumed the widest possible stance while standing.

The second group performed dynamic stretching, completing five repetitions per leg with a 2–3 second hold (Hockey, n.d.).

*Walking Quad Stretch*. Participants kept their backs straight and brought one heel toward the buttock.

*Knee to Chest*. While moving forward, participants pulled one knee up to the chest, raising it as high as tolerable.

*Walking Lunge*. Participants lunged forward with one leg while keeping the trunk straight and avoiding contact of the rear knee with the ground.

*Straight Leg March*. Participants alternated leg extensions in a straight line while walking.

*Crawl Stretch*. With legs together, participants stood upright, bent forward, and walked their hands forward until their back was straight.

*Cradle Hip Walk*. While moving forward, participants pulled the right foot inward and up, rotating the knee outward.

The study focused on selected students as participants to assess the effects of static and dynamic stretching exercises on lower extremity performance. Ten participants were divided into two groups through a fishbowl selection technique, giving all candidates an equal chance to be selected. The participants were divided into two equal experimental groups based on the following criteria: Bonafide student; Male; and Member of Men’s Volleyball Team for School Year 2023–2024.

The study used a tape measure to assess the participants' vertical jump (Schunzel, 2021). A standing vertical jump was performed prior to the assigned stretching exercises. Each participant jumped beside a wall and tapped it using chalk or tape on their middle finger at their highest point (Santos et al., 2022). The observer measured and recorded the peak jump. After two weeks of stretching, the participants repeated the test to determine any changes in performance.

Consent was obtained from both the school and the participants. The researcher secured written permission from the school principal to conduct the study. A letter explaining the study's purpose and importance was provided to the participants, along with a parental consent form, ensuring that the students were physically and emotionally fit to participate.

A pre-test was conducted before the intervention, with trials for each participant. After the two-week stretching program, held at least three times per week (ACSM, 2021), a post-test using the same measures was administered.

The static stretching (SS) group performed six stretches for 30 seconds per leg (Master, 2021), while the dynamic stretching (DS) group performed six exercises with five repetitions and a 2–3 second hold per leg (Hockey, n.d.). All data collected over the two weeks were documented and analyzed statistically.

The study considered ethical principles such as informed consent, participant safety, and the protection of anonymity, confidentiality, and privacy. A letter was given to participants explaining the nature and purpose of the study. Participants were informed of the study's objective, duration, their right to withdraw at any time, and the use of collected data. The researcher committed to storing the data securely for at least three years. Afterward, digital data would be permanently deleted using specialized software, and physical data would be disposed of in an environmentally responsible manner.

Data were analyzed using mean and paired t-test.

## 4. Results and Discussion

Table 1 presents the vertical jump height measurements before and after the static stretching intervention, along with their corresponding mean and standard deviation (SD) values. The pre-test recorded a mean jump height of 22.10 cm (SD = 3.130), while the post-test measurement showed an increased mean of 26.60 cm (SD = 2.632). This substantial improvement in performance suggests that static stretching may positively influence lower extremity explosive strength when applied consistently over time.

**Table 1**

*Lower extremity performance (vertical jump height) before and after the static stretching intervention*

| | **Mean (inches)** | **SD** |
|---|---|---|
| Pre-test | 22.10 | 3.130 |
| Post-test | 26.60 | 2.632 |

Recent evidence supports the idea that regular static stretching can lead to improvements in performance-related parameters. For example, Esteban-García et al. (2024) concluded in their meta-analysis that both static and dynamic stretching interventions in warm-up routines significantly improved jump height and joint range of motion in physically active individuals. Similarly, Arntz et al. (2024) emphasized that chronic static stretching protocols may enhance muscle hypertrophy and neuromuscular performance over time, likely contributing to better power output in movements like jumping.

While acute static stretching has historically been associated with temporary decreases in strength or power output (Behm & Chaouachi, 2011; McHugh & Cosgrave, 2009), emerging studies reveal that the duration, context, and frequency of stretching are key to understanding its impact. For instance, Donti and Bogdanis (2025) noted that static stretching, when used as part of a recovery and adaptation strategy, may enhance muscle function and reduce injury risk. Faelli et al. (2021) also demonstrated that both static and dynamic stretching improved running economy and perceived effort in endurance athletes, suggesting a broader application for performance enhancement.

In the current study, participants underwent a two-week static stretching intervention. The consistent application of six targeted lower limb stretches, performed regularly, likely contributed to improved muscle compliance, increased joint range of motion, and enhanced neuromuscular coordination, all factors that have been shown to positively influence vertical jump performance (Babault et al., 2021; Handrakis et al., 2010). These findings align with Samson et al. (2012), who indicated that sport-specific warm-ups incorporating stretching improved explosive performance measures.

Thus, this increase in vertical jump height supports the growing body of evidence that static stretching, when integrated appropriately over a period of time rather than immediately prior to maximum exertion, can improve performance metrics such as lower-body power.

**Table 2**

*Lower extremity performance (vertical jump height) before and after the dynamic stretching intervention*

| | **Mean (inches)** | **SD** |
|---|---|---|
| Pre-test | 22.60 | 3.732 |
| Post-test | 23.40 | 4.144 |

Table 2 displays the vertical jump height before and after the dynamic stretching intervention, including the corresponding mean and standard deviation (SD) values. The pre-test recorded a mean of 22.60 cm with a standard deviation of 3.732, while the post-test showed a modest increase in performance, with a mean of 23.40 cm and a standard deviation of 4.144. Although the improvement was not as substantial as that observed in the static stretching group, the results suggest a slight positive effect of dynamic stretching on lower extremity power.

According to Opplert and Babault (2018), dynamic stretching can enhance performance by improving range of motion (ROM), which is primarily attributed to reduced stiffness of the muscle-tendon unit. The improved muscular output is also associated with temperature elevation and potentiation-related mechanisms triggered by the voluntary muscular contractions involved in dynamic stretching.

Dynamic stretching is known to mimic sport-specific movements, which may facilitate neuromuscular activation and enhance readiness for physical activity (Chaabene et al., 2019; Behm et al., 2023). This activation contributes to better synchronization of muscle recruitment, which can benefit explosive movements like jumping. However, the relatively limited improvement in this study may be due to the short duration of the intervention or the participants' baseline physical condition. Additionally, Zvetkova et al. (2023) emphasized the biomechanical and therapeutic benefits of stretching, including enhanced flexibility and injury prevention, which are essential for optimizing athletic performance. Similarly, Bouguezzi et al. (2023) advocate for recognizing flexibility, as improved through stretching, as a critical component of physical fitness, especially in performance settings that require explosive or agile movements.

Furthermore, recent systematic reviews have identified evidence gaps in the optimal application of stretching techniques, highlighting that factors such as stretching type, duration, intensity, and population characteristics significantly influence the outcomes (Afonso et al., 2024). For instance, although dynamic stretching is often recommended during warm-up routines, its effects on explosive strength are more nuanced and may depend on movement specificity and timing. The minor increase in jump performance observed may also be influenced by muscle damage prevention and ionic regulation mechanisms as described by Allen et al. (2005), who noted that controlled stretching can maintain muscle function and prevent overstretch-induced impairments.

While the dynamic stretching intervention yielded a small improvement in vertical jump height, this aligns with existing literature that supports the acute neuromuscular and ROM-related benefits of dynamic stretching. However, for more pronounced gains in explosive performance, longer interventions or combined warm-up strategies may be necessary (Rosenfeldt et al., 2024; Mehraban Jahromi et al., 2024).

**Table 3**

*Comparison of pre-test and post-test vertical jump height of the static stretching intervention*

| | **Pre – assessment** | **Post – assessment** | **Difference** | **Sig. (2-tailed)** | **Remarks** |
|---|---|---|---|---|---|
| Vertical jump height | 22.10 | 26.60 | -4.50 | .011 | Reject the Null Hypothesis |

If Sig. (2-tailed) ≤ .05, then difference is Significant. Reject null hypothesis.

If Sig. (2-tailed) > .05, then difference is Not Significant. Accept null hypothesis

A paired samples t-test was utilized to evaluate the significant difference between the pre-test and post-test vertical jump heights following the static stretching intervention. The analysis revealed that the improvement in vertical jump performance was statistically significant, with a p-value of .011, which is less than the conventional alpha level of .05. This result led to the rejection of the null hypothesis, indicating that the static stretching intervention had a measurable effect on the participants' vertical jump height.

The significant difference observed between the pre- and post-test results suggests that regular static stretching contributed to enhanced lower limb performance. This finding aligns with the results of Sandberg et al. (2012), who reported that static stretching of specific muscle groups such as the hip flexors and ankle dorsiflexors can improve vertical jump height and power output by increasing flexibility and joint mobility. Improved muscle-tendon unit elasticity may also reduce resistance during muscle contraction, thereby enhancing explosive movements such as jumping.

The physiological rationale behind this improvement is further supported by literature indicating that chronic static stretching enhances muscle length, neuromuscular efficiency, and range of motion, all of which are crucial for optimal performance in power-based activities (Arntz et al., 2024; Babault et al., 2021). Over time, consistent static stretching can lead to structural adaptations in muscles and tendons, which may improve force production and reduce muscular inhibition, contributing to improved jump mechanics and height.

These findings contribute to a growing body of evidence that supports the inclusion of structured static stretching routines not only for flexibility or injury prevention, but also for improving performance in tasks requiring explosive strength, when used over an extended period and not immediately before maximal exertion efforts.

**Table 4**

*Comparison of pre-test and post-test vertical jump height of the dynamic stretching intervention*

| | Pre – assessment | Post – assessment | Difference | Sig. (2-tailed) | Remarks |
|---|---|---|---|---|---|
| Vertical jump height | 22.60 | 23.40 | -.80 | .078 | Accept the Null Hypothesis |

A paired samples t-test was conducted to determine whether there was a statistically significant difference between the pre-test and post-test vertical jump heights following the dynamic stretching intervention. The test result showed a p-value of .078, which is greater than the conventional significance level of .05. Therefore, the result was not statistically significant, and the null hypothesis was not rejected. This indicates that the dynamic stretching intervention did not produce a significant improvement in vertical jump performance over the two-week period. Although there was a slight increase in the mean jump height from pre-test to post-test, the change was not substantial enough to confirm that dynamic stretching alone was responsible for the improvement. Several factors may explain this outcome.

According to Calvert (2023), dynamic stretching is particularly beneficial for endurance athletes, as it helps improve running economy, movement efficiency, and joint mobility. However, because endurance sports generally involve lower muscle strain and explosive power demands compared to high-impact activities like sprinting or jumping, the neuromuscular adaptations brought by dynamic stretching may not be as pronounced in explosive movements such as vertical jumping. In this study, the performance task focused on explosive lower limb power, which may require different warm-up or training stimuli, such as plyometrics or strength training, for significant improvements.

Furthermore, studies such as Behm et al. (2023) and Chaabene et al. (2019) suggest that while dynamic stretching can acutely enhance muscle activation and range of motion, the duration, frequency, and specificity of the movements must closely match the target activity for the benefits to translate into improved performance. In this case, the short duration of the dynamic stretching intervention (two weeks) and the non-specific nature of some stretches to vertical jumping may have limited its effectiveness. In addition, Afonso et al. (2024) highlight that despite the widespread use of dynamic stretching in warm-up routines, research on its chronic performance effects remains inconclusive, especially when applied in isolation. Stretching interventions that lack resistance-based or plyometric components may not provide sufficient overload to stimulate adaptations in explosive power.

While dynamic stretching offers several functional benefits, its isolated implementation in this context did not lead to statistically significant gains in vertical jump performance. Future studies may consider combining dynamic stretching with other modalities, extending the duration, or ensuring exercise specificity to better assess its impact on jump-related outcomes.

## 5. Conclusion

The research indicates that dynamic stretching may have a negative impact on lower extremity performance when performed prior to activities requiring explosive movements or high-intensity efforts. Therefore, it is advisable to minimize dynamic stretching exercises before such activities. Instead, dynamic stretching may be better suited for post-exercise or cooldown routines. It is important to recognize that individuals may respond differently to stretching exercises. Some may benefit from a combination of static and dynamic stretching, while others may find dynamic stretching more effective. Personalizing stretching routines based on an individual's goals, fitness level, and specific needs can optimize their effects on lower extremity performance. The timing of stretching exercises may also play a significant role in their impact on performance. Future studies could explore the effects of pre-exercise, post-exercise, and independent stretching sessions to determine the optimal timing for various stretching modalities.

This study provided valuable insights into the effects of static and dynamic stretching exercises on lower extremity performance. The findings suggest that static stretching is beneficial for enhancing strength, power, and flexibility, whereas dynamic stretching may have a lesser impact on performance. These conclusions emphasize the importance of tailoring stretching routines to optimize lower extremity performance while considering individual variations in response to different stretching modalities. By incorporating static stretching into warm-up routines and limiting dynamic stretching before high-intensity activities, individuals can maximize their potential for peak lower extremity performance.

Based on the findings of this study, it is recommended to include static stretching exercises as part of the warm-up routine before engaging in activities that require lower extremity performance. Static stretching has been shown to have positive effects on strength, power, and flexibility, all of which can enhance overall performance. While this study focused on the effects of static and dynamic stretching exercises, future research could investigate other variables that may influence lower extremity performance. Factors such as the duration, frequency, and intensity of stretching exercises, as well as the influence of age, gender, and fitness level, could be explored to gain a more comprehensive understanding of their effects.

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