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Short-Term Effects of Cyclic vs. Ballistic Stretching on Jumping Distance in Undergraduate Students

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ABSTRACT

Standing broad jump distance is a widely used measure to assess leg strength and athletic performance, especially in sports requiring horizontal propulsion. Pre-exercise stretching has been shown to influence power output, a critical component of jumping. This study aimed to compare the effects of lower limb cyclic stretching (CS) and ballistic stretching (BS) on jumping performance, as measured by the standing broad jump test, among undergraduate students. This is a quasi-experimental study that recruited 44 undergraduate students from UTAR, Sungai Long Campus. Participants were randomly assigned to either the CS group or the BS group, with 22 students in each. Both groups performed three specific lower limb stretches targeting the iliopsoas, hamstrings and gastrocnemius muscles. Each participant completed a pre-test, stretching intervention and post-test within a single day at the physiotherapy centre. The mean age of participants was 20.55 ± 1.06 years in the CS group and 19.73 ± 1.20 years in the BS group. In the CS group, the mean difference (MD) in jumping distance between pre- and post-stretching was −1.22 cm ($p > 0.05$), while in the BS group, it was −0.06 cm ($p > 0.05$). No statistically significant difference was observed between the two groups (MD = −1.16 cm, $p > 0.05$). Neither cyclic stretching nor ballistic stretching of the lower limbs produced a significant improvement in jumping distance among undergraduate students. Furthermore, there was no significant difference between the effects of the two stretching techniques on horizontal jump performance.

1. Introduction

Jumping is an essential component of athletic performance and is frequently used as an indicator of lower limb power in sports and physical assessments. It is a fundamental movement in various sporting disciplines, including track and field, basketball, volleyball and soccer [1]. The ability to jump efficiently reflects the strength and explosive power of the lower body and studies have shown a

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strong correlation between jumping performance and other physical attributes such as sprint speed and anaerobic capacity [2].

Stretching, as a preparatory activity, plays a significant role in enhancing physical performance, preventing injuries and promoting flexibility. Stretching exercises are commonly performed prior to bodily activity to prepare the muscles and joints for the demands of sport or exercise. McMillian *et al.,* [3] demonstrated that stretching before activity can positively influence performance outcomes such as jumping distance and height. Various stretching modalities have been implemented in athletic settings to improve muscle performance and functional outcomes. These include static stretching (SS), dynamic stretching (DS), proprioceptive neuromuscular facilitation (PNF), ballistic stretching and cyclic stretching. Each stretching technique has its characteristics, benefits and limitations, depending on the nature of the activity and the individual goals [4].

Dynamic stretching has garnered attention in recent years for its potential to enhance performance through mechanisms such as increased muscle temperature, improved neuromuscular efficiency and post-activation potentiation [5]. Unlike static stretching, which involves holding a muscle in a lengthened position for an extended period, dynamic stretches involve movement-based stretches that mimic the activity to follow. Ballistic and cyclic stretching are two types of dynamic stretching methods that involve repeated or bouncing movements to elongate the muscle-tendon unit and improve the range of motion [6].

Cyclic stretching (CS) is defined as a controlled, intermittent stretch where the muscle is repeatedly stretched and released in a slow, gradual manner. The stretch is usually held for about 5 to 10 seconds before being released, with gentle intensity and slow velocity, allowing the muscle to adapt to the stretch gradually [7]. It is often confusing with static stretching due to the short hold duration; however, its dynamic nature of repeated application differentiates it [8]. On the other hand, ballistic stretching (BS) involves rapid, forceful bouncing movements that attempt to push the muscle beyond its typical range. This technique is performed at a high velocity and intensity, often using momentum to increase flexibility and performance outcomes [9]. While effective in specific athletic populations, ballistic stretching has been associated with an increased risk of injury if not correctly executed, particularly in untrained individuals [7].

The physiological responses induced by these stretching modalities vary significantly. Stretching, in general, contributes to improved flexibility, muscle-tendon compliance and joint range of motion, all of which play vital roles in athletic efficiency [10]. Regular flexibility exercises are recommended at least twice a week, with individual stretches held at a point of tightness or mild discomfort for up to 30 seconds and a total stretching time of about 60 seconds per muscle group [11,12]. The underlying mechanisms through which stretching impacts performance include changes in the viscoelastic properties of the muscle-tendon unit, modifications in motor unit recruitment, increased neuromuscular efficiency and temperature-mediated effects on muscle contractility [13,14].

Samozino *et al.,* [15] suggested that maximal jumping, whether vertical or horizontal, requires the rapid extension of the lower limbs and the generation of significant force during the push-off phase. This action results from the acceleration of the body mass from a resting position, influenced by the resultant force and lower extremity mechanics. Studies have explored the morphological and physiological factors associated with maximal jumps. Still, relatively few have examined the influence of specific stretching techniques on horizontal jump outcomes, such as the standing broad jump [14].

The standing broad jump is commonly used in training programs for sports requiring explosive horizontal movement. Maulder *et al.,* [16] identified it as a reliable predictor of sprinting ability and found it to be potentially more helpful than vertical jumping in some athletic assessments. Despite the widespread use of stretching in training routines, there remains a lack of conclusive evidence regarding the most effective type of stretching to enhance jumping distance, particularly in healthy, active individuals such as undergraduate students. While dynamic stretching is generally favoured over static stretching for performance enhancement, limited studies have compared the effectiveness of cyclic and ballistic stretching on jump-specific outcomes [9].

Hough *et al.,* [17] reported that static stretching before performance activities could have detrimental effects on jump height, whereas dynamic stretching was associated with improved performance. Similarly, Thomas *et al.,* [18] emphasized the importance of selecting appropriate pre-participation stretching techniques to prevent injuries and enhance muscular output, advocating for further research to clarify the impact of different methods. Despite the recognition of the benefits of dynamic stretching, there is a need to differentiate the effects of specific types, such as cyclic and ballistic stretching, in sport-specific tasks like jumping.

This background informs the current study's assessment and comparison of the immediate effects of ballistic and lower limb cyclic stretching techniques on undergraduate students' jumping performance as measured by the standing broad jump test. The study intends to ascertain whether one approach affects jump distance more significantly than the other and whether the results are transferable to sports training and recovery environments. Additionally, it seeks to give coaches, physiotherapists and players helpful advice on how to choose stretching techniques that will optimize performance while lowering the chance of injury.

2. Methods

This quasi-experimental study involved two groups of undergraduate students. Both participants and the researcher were aware of the group assignments due to the practical nature of the intervention; however, statistical analysis was conducted in a blind manner to reduce bias [19]. Participants were recruited from the KA and KB blocks of Universiti Tunku Abdul Rahman (UTAR), Sungai Long Campus, located in Cheras, Malaysia. Recruitment was conducted in person and completed over one week. The intervention was carried out in the Physiotherapy Centre located in the KA block of the UTAR Sungai Long Campus. The entire experimental phase was conducted over a period of two weeks following the completion of recruitment.

Before participating, everyone was given a thorough explanation of the study procedure. Participants were required to read and sign an informed consent form and provide their demographic information. Ethical clearance for this study was obtained from the Scientific and Ethical Review Committee (SERC) of Universiti Tunku Abdul Rahman.

The study targeted undergraduate students from UTAR, Sungai Long Campus. Sample size estimation was calculated using G*Power 3.1.9.4 software based on a mixed-method ANOVA, with an alpha level of 0.05 and a power of 80%. The calculation indicated a minimum of 34 participants was needed. To account for a potential 20% dropout rate, the study recruited 44 participants, with 22 allocated to each group.

Participants were selected based on the following inclusion criteria:

i. currently enrolled undergraduate students at UTAR Sungai Long Campus
ii. both male and female participants
iii. physically active individuals as determined by the International Physical Activity Questionnaire-Short Form (IPAQ-SF) [20].

Exclusion criteria included:

i. elite-level athletes
ii. history of spinal or lower limb injuries [8]
iii. any cardiovascular or pulmonary conditions
iv. overweight or obese individuals with a BMI of 25 kg/m² or higher [21]
v. recent fractures
vi. recent trauma to the lower limbs.

After screening, eligible participants completed demographic and IPAQ-SF forms. Participants were then randomly assigned to one of two groups. Appointments were scheduled for intervention sessions. Prior to each session, participants' heart and respiratory rates were measured to ensure they were at rest. If elevated, they were asked to rest until normal values were reached. All participants were instructed to wear appropriate sports clothing and footwear. A five-minute jogging warm-up was performed before the pre-test.

Participants were divided into two intervention groups: one received cyclic stretching (CS) and the other received ballistic stretching (BS). The stretching protocols targeted lower limb muscles, including the quadriceps, iliopsoas, gluteal muscles, hamstrings and gastrocnemius, based on methods described by Jaggers *et al.,* [22]. Each participant completed the full protocol in one session, including both pre-test and post-test assessments. The difference in jump distance before and after stretching was recorded for analysis.

Jump performance was measured using the standing broad jump (SBJ) test. A measuring tape was used to record the distance in centimetres. Participants began with both feet behind a starting line marked at 0 cm. Chalk powder was applied to their heels. They were instructed to bend their knees, swing their arms and jump forward with both feet, aiming to land simultaneously without losing balance. The distance between the starting point and the heel mark upon landing was recorded. Each participant performed three trials and the longest jump was considered for analysis. To ensure safety, participants wore sports shoes and the jump area was kept clear of any obstacles.

The SBJ test is a valid and reliable measure of lower body strength [23]. It has demonstrated excellent test-retest reliability, with intraclass and interclass correlation coefficients both reported at $r = 0.99$ [24]. All data collected during the study were analysed using IBM SPSS software, version 28.0.

3. Results

3.1 Demographic Analysis

Table 1 presents the demographic characteristics of participants in the Cyclic Stretching (CS) group and Ballistic Stretching (BS) group. The mean age of participants in the CS group was 20.55 years (SD = 1.06), while the BS group had a mean age of 19.73 years (SD = 1.20).

In terms of gender distribution, each group consisted of 18 male participants (81.8%) and 4 female participants (18.2%).

Regarding body mass index (BMI), the CS group had a mean BMI of 21.63 kg/m² (SD = 2.14), while the BS group had a mean BMI of 21.68 kg/m² (SD = 2.04).

Table 1
Demographic data of the participants

Demographic data		Cyclic stretching (CS)		Ballistic stretching (BS)	
		Frequency (%)	M (SD)	Frequency (%)	M (SD)
Age in years			20.55 ± 1.06		19.73 ± 1.20
	18	1 (4.5)		4 (18.2)	
	19	2 (9.1)		5 (22.7)	
	20	7 (31.8)		8 (36.4)	
	21	8 (36.4)		3 (13.6)	
	22	4 (18.2)		2 (9.1)	
Gender	Male	18 (81.8)		18 (81.8)	
	Female	4 (18.2)		4 (18.2)	
Race	Chinese	22 (100)		21 (95.5)	
	Indian			1 (4.5)	
BMI			21.63 ±2.14		21.68 ±2.04
Year of study	1	6 (27.3)		14 (63.6)	
	2	8 (36.4)		7 (31.8)	
	3	6 (27.3)			
	4	2 (9.1)		1 (4.5)	

3.2 Inferential Analysis

The Shapiro-Wilk test of normality indicated that the jumping distance data for both the pre-stretching and post-stretching conditions in the Cyclic Stretching (CS) and Ballistic Stretching (BS) groups were normally distributed ($p > .05$). Therefore, a paired samples *t*-test was employed to evaluate the differences in mean jumping distance scores between the pre-stretching and post-stretching measurements within each group.

Table 2
Paired 't' test analysis

Groups	Pre-stretching mean ± S. D	Post stretching mean ± S. D	Mean differences	Sig (P value)
Cyclic Stretching	200.70cms	199.49cms	-1.22cm	0.35
Ballistic Stretching	197.45cms	197.39cms	-0.06cm	0.49

Table 3
Independent 't' test analysis

Groups	Cyclic stretching mean ± S. D	Ballistic stretching mean ± S. D	Mean differences	t value	Sig (P value)
	199.49 cms	197.39 cms	-2.1cms	-0.294	0.770

The mean difference in jumping distance between the pre-stretching and post-stretching conditions in the Cyclic Stretching (CS) group was −1.22 cm (SD = 14.97 cm), while the Ballistic Stretching (BS) group showed a mean difference of −0.06 cm (SD = 11.11 cm). Statistical analysis revealed no significant difference in jumping distance between the two stretching methods ($p > .05$), indicating that neither CS nor BS had a statistically significant effect on jumping performance.

4. Discussion

The present study aimed to evaluate the short-term effects of cyclic stretching (CS) and ballistic stretching (BS) on jumping distance among undergraduate students. Based on the findings, no statistically significant differences ($p > 0.05$) were found in jumping performance between pre- and post-stretching in both CS and BS groups. This indicates that neither CS nor BS had a meaningful impact on horizontal jumping performance as assessed by the standing broad jump (SBJ) test.

Specifically, the mean jumping distance in the CS group decreased by 1.22 cm post-intervention, though this reduction was not statistically significant. This aligns with previous findings suggesting that CS has limited or even adverse effects on strength and power output [17,25]. Herda *et al.,* [26] observed increased EMG activity following CS, yet without concurrent strength gains. Furthermore, researchers demonstrated that increased muscle compliance resulting from CS could alter the muscle length-tension relationship, reducing force production efficiency due to extended sarcomere length and velocity of shortening [27,28].

Similarly, the BS group exhibited a negligible decrease of 0.06 cm in jumping distance post-stretching, which was also statistically insignificant. Although BS is generally known to improve flexibility through neural mechanisms, studies have shown it may reduce muscle strength by inhibiting Golgi tendon organ activity and decreasing motor neuron excitability [29,30]. This was further evidenced by reduced H-reflex amplitudes and EMG activity post-stretching, indicating decreased motor output [30].

Many research works have been reported no significant improvements in vertical jump performance following BS, which supports the current findings [31,32]. Although BS may enhance flexibility, its role in strength or power-based tasks such as jumping remains unclear. Furthermore, the timing of the SBJ test immediately following stretching could have contributed to the lack of observed improvement. Little *et al.,* [33] suggested that immediate testing post-stretching may suppress potential performance gains [33]. Similarly, Jaggers *et al.,* [22] and the current study administered the jump test immediately after the stretching protocols, possibly before neuromuscular adjustments could take effect. Studies also emphasized that improvements in SBJ require more than stretching alone [1,5]. Factors such as posture, neuromuscular coordination and explosive strength significantly influence performance.

Despite its valuable insights, this study had notable limitations. The participant pool was restricted to physically active undergraduate students, primarily powerlifters and basketball players, which limits generalizability. Flexibility or joint stiffness patterns, which may influence performance, were not assessed. Self-reported activity data via IPAQ-SF may have been affected by recall bias, especially due to fluctuations in routine during academic breaks. Variability in test conditions, including balance issues and inconsistent motivational cues during the SBJ test, may have introduced measurement error. The small, homogenous sample—predominantly Chinese students aged 18-22 from a single institution—further reduces the external validity of the results.

For future research, it is recommended that a more diverse and representative sample be recruited, including participants from multiple sports disciplines, age groups and institutions. Flexibility and strength assessments should be incorporated to understand the underlying mechanisms better. Standardized SBJ protocols, such as using video analysis and consistent motivational instructions, are encouraged to enhance reliability. These improvements will help develop more conclusive evidence on the role of stretching in physical performance.

5. Conclusion

This study concluded that there was no significant improvement in jumping distance after cyclic or ballistic stretching among undergraduate students. There was also no significant difference between the effects of the two stretching methods. Gender did not influence the outcomes. These results suggest that neither stretching method significantly enhances lower limb power. Future studies with larger samples and varied participant characteristics are recommended to explore more effective stretching protocols.

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Authors Contribution

Ng Zi Ru was involved in conceptualizing and planning research, performing data collection, analysing the data and drafting the manuscript. Mahadevi Barathi contributed to the research design, interpretation of the results and provided critical revisions to the manuscript. Arun B assisted in drafting the manuscript, designing the figures and reviewing the final version. All authors have read and approved the final manuscript.

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