ORIGINAL ARTICLE

Effect of lower extremity joint distraction exercises during warm-up on range of motion, flexibility, and jump performance in female volleyball players

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim: Effective warm-up routines are critical for enhancing athletic performance and reducing injury risk. Joint distraction exercises are hypothesized to improve range of motion (ROM), flexibility, and jump performance, yet their effects are not well-documented in volleyball. This study aims to investigate the impact of joint distraction exercises applied to the lower extremities during warm-ups on ROM, flexibility, and jump performance in female volleyball players.

Material and Methods: Twenty-four female volleyball players voluntarily participated in this study. The standard protocol included routine warm-ups followed by pre-tests measuring flexibility, range of motion (ROM), vertical jump (VJ), and horizontal jump (HJ). After a 48-hour rest period to minimize fatigue effects, the athletes underwent joint distraction exercises using elastic bands targeted at the lower extremities. Post-tests were conducted after these specific warm-up exercises to assess any changes. Data analysis was performed using SPSS software.

Results: The study found no significant difference in hip flexion range of motion (ROM) scores following joint distraction exercises ($p > 0.05$). However, statistically significant improvements were observed in overall flexibility, ankle dorsiflexion ROM, and both vertical and horizontal jump performances ($p < 0.05$).

Conclusions: The study demonstrates that joint distraction exercises during warm-ups significantly enhance flexibility, range of motion (ROM), and jump performance in female volleyball players. Incorporating these exercises into routine warm-ups could be crucial for optimizing athletic performance and potentially reducing injury risks.

Keywords: warm-up, jumping, distraction, flexibility, range of motion

Introduction

In competitive sports such as volleyball, optimizing physical performance while minimizing injury risk is paramount. Despite the critical role of warm-ups in preparing athletes for peak performance, traditional routines often overlook targeted techniques that could enhance key attributes for volleyball players, such as flexibility, range of motion (ROM), and jump capabilities. Joint distraction exercises, particularly those applied to lower extremities using elastic bands, have emerged as a promising approach to enhance these physical qualities. Yet, the specific effects of these exercises during warm-ups have been underexplored, particularly in female volleyball players.

The importance of specialized warm-up techniques becomes even more evident considering the dynamic nature of volleyball, a sport characterized by open-skill movements performed at varying speeds [1]. These movements can lead to various injuries, including ankle and cruciate ligament injuries [2], which underscores the need for effective preventive strategies. Warm-up exercises play a crucial role in mitigating these injury risks and preparing athletes for the demands of the game. Various methods are employed in warm-ups to prevent sports injuries and increase flexibility [3]. Stretching exercises, which raise body temperature, prevent adhesions between soft tissues and bones, and enhance joint range of motion (ROM), are considered essential. Techniques such as static, ballistic, and dynamic stretching, along with proprioceptive neuromuscular facilitation (PNF), are commonly used during warm-ups to increase ROM [5, 6, 7, 8]. The exploration of joint distraction exercises fits into this context as a potentially valuable addition to the warm-up routines, promising enhanced flexibility and reduced injury risk without the downsides of traditional stretching

doi:10.15561/26649837.2024.0405

methods.

Warm-up routines have been documented to improve various performance parameters such as strength, power, agility, sprint performance, vertical jump height, and electromyography activity during isometric muscle contractions [9]. Notably, compared to other stretching methods, dynamic stretching performed at various intensities is particularly effective at increasing body temperature, motor unit excitability, muscle activation time, kinaesthetic awareness, and range of motion (ROM) when used as part of a pre-exercise warm-up [10]. An alternative approach involves warm-up exercises with elastic bands, which can trigger post-activation potentiation (PAP) to enhance flexibility, ROM, sprint, agility, and jump performances [11, 12].

Building on these foundations, joint distraction exercises represent an innovative application of elastic bands in warm-up routines, specifically designed to boost athletic performance. These exercises have been shown to improve the maximum strength performance of lower extremity muscles and are aimed at enhancing ROM through increased synovial fluid production, which reduces friction between joint surfaces, facilitating smoother joint movements [12, 13, 14, 15]. Enhanced ROM is directly linked to improved sports performance, as it allows for greater muscular extension and retraction during athletic activities [16, 17].

Moreover, limited ROM, particularly in ankle dorsiflexion, has been identified as a significant risk factor for injuries in sports that involve intensive jumping, such as volleyball. Restrictions in ankle dorsiflexion can lead to a range of sports injuries, including cruciate ligament injuries, overuse disorders, patella injuries, Achilles tendinopathy, tibial shin splints, and anterior patella femoral pain syndrome [19, 20, 21]. Such limitations can alter knee valgus motion during jumping and squatting, disrupting the kinetic chain and potentially creating harmful force demands on the upper body [22]. Therefore, it is increasingly recognized that training through a full range of motion is essential to maximize the effectiveness of exercise routines and prevent injuries [23].

In summary, the existing body of research underscores the critical role of warm-ups in enhancing performance and preventing injuries among athletes, particularly in sports demanding high levels of physical exertion like volleyball. The documented benefits of advanced stretching methods, including dynamic and joint distraction exercises, have highlighted significant improvements in range of motion, flexibility, and sport-specific performance outcomes. However, despite these advances, the precise impact of joint distraction exercises during warm-ups has received limited attention, especially concerning their acute effects on volleyball players. This gap in the literature necessitates focused research to optimize warm-up protocols that could further benefit athletic performance and injury prevention.

In line with all this information, the main purpose of our study is to examine the acute effect of joint distraction exercises applied to the lower extremities during warm-up on range of motion and jumping performance in female volleyball players.

Materials and Methods

Participants

This study involved 24 female volleyball players from the Women's 2nd League of the Turkish Volleyball Federation in Istanbul. The participants had an average age of 17.71 ± 2.57 years, an average height of 174.87 ± 8.46 cm, and an average body weight of 66.79 ± 7.67 kg. All participants were actively competing, held a sports license, and had no knee injuries that could impede their range of motion, aligning with the study's inclusion criteria. Ethical approval was obtained from the Ethics Committee of Sakarya University of Applied Sciences (E-26428519-050.99-96228).

Research Design

The height (cm) and body weight (kg) of each participant were measured using a portable stadiometer and a TEM ECHO device, respectively, to ensure accuracy for subsequent jump tests analyzed via camera. Measurements were taken without shoes to ensure precision. The research protocol was adapted from the study by Çağlın et al. [14] and further details of the protocol are illustrated in Figure 1.

Initially, athletes underwent a 10-minute warm-up consisting of 5 minutes of walking followed by 5 minutes of running. Subsequently, vertical jump (VJ), horizontal jump (HJ), and flexibility-range of motion (ROM) tests were conducted at one-minute intervals. Two days later, the athletes performed lower extremity (hip-knee-ankle) joint distraction exercises consisting of 2 sets of 30 seconds with 15 seconds of rest between sets, following another 10-minute warm-up (Figure 2). Tests were replicated 5 minutes after completing the joint distraction exercises. All tests were administered in the same hall, at the same time of day, and with a two-day interval between sessions.

Testing Procedures

Vertical Jump (VJ): In the vertical jump test, athletes performed a squat on a non-slip flat surface, positioning their feet at a comfortable width. From the squat position, they were instructed to jump as high as possible using their full strength. No verbal encouragement or commands were given during the test to ensure consistency. The jumps were recorded using an iPhone 13 Pro equipped with a 60-fps video camera. The height of each jump was measured

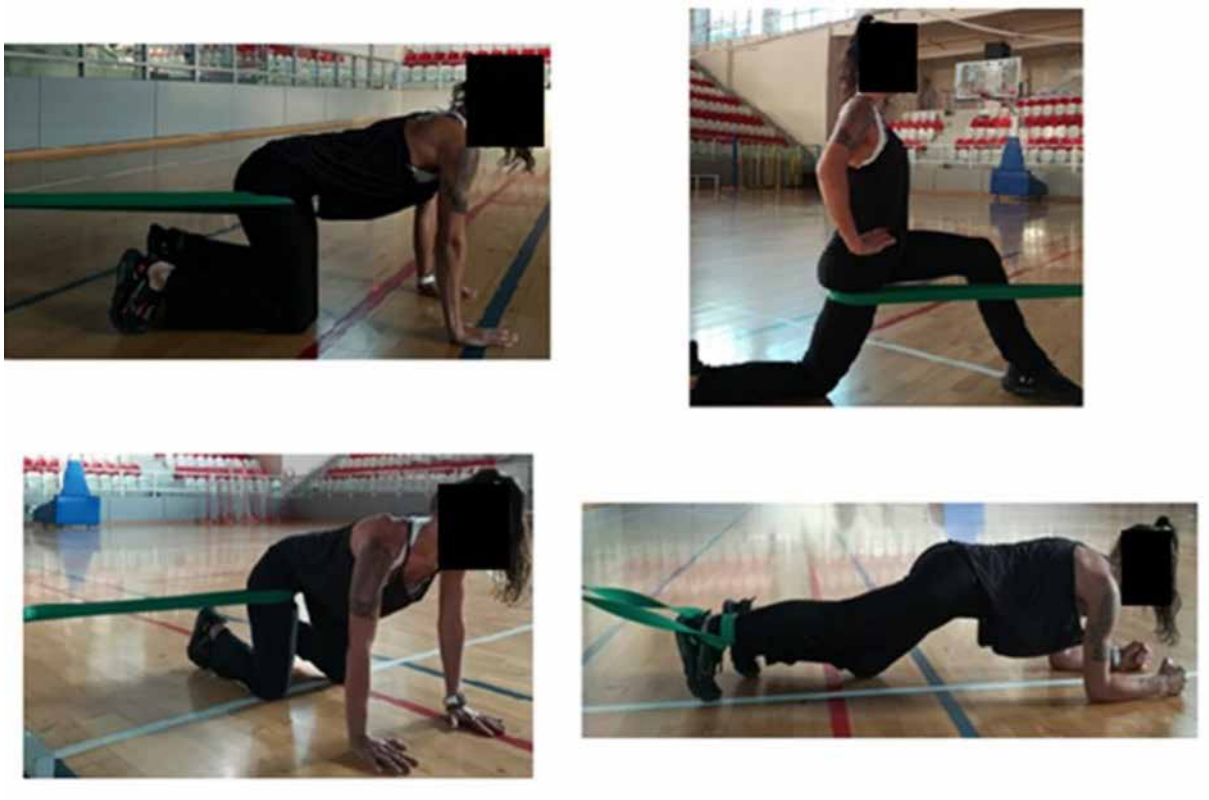

Figure 1. Experimental procedure.

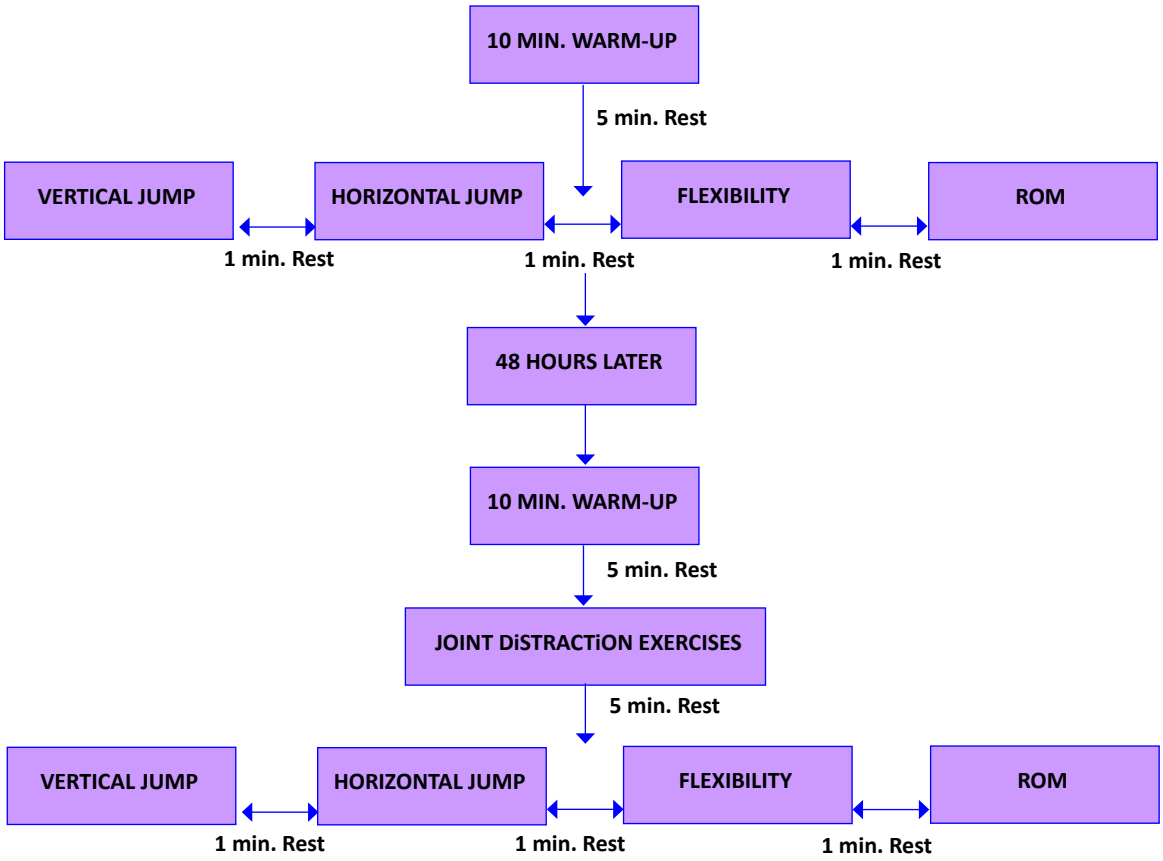

Figure 2. Joint distraction exercises

using the MyJump 2 mobile application [24].

Horizontal Jump (HJ): For the horizontal jump test, athletes were asked to jump horizontally from a marked line to the farthest point they could reach. The jumps were also recorded with an iPhone 13 Pro from both a height and a side angle to capture the entire jump trajectory. The distance of each jump was measured using the MyJump 2 smartphone application, with markings taken from the athletes' toes before the jump and heels after the jump [24].

Range of Motion (ROM): Athletes were asked to lie on their backs on a mat with both ankles and knees fully extended. Using the My Jump 2 app, which is validated for accuracy and reliability [24], an iPhone 13 Pro was positioned between the athlete's kneecap and the midpoint of the femur. Athletes were instructed to lift the straight leg as high as possible within 5 seconds.

Performed without shoes, athletes were asked to perform a lunge with one foot forward, touching the ground. The iPhone 13 Pro was placed in line with the midpoint of the tibia below the kneecap to measure dorsiflexion using the MyJump 2 app. Athletes were required to push their knee forward without lifting the heel for 5 seconds.

Flexibility Test (Sit and Reach): A sit-and-reach test was conducted using a specialized bench (Model 01285A, Lafayette, USA) with an 80 cm measurement length and 0.1 cm sensitivity. Athletes sat on the ground with legs extended straight, feet placed five centimeters apart with toes pointing upward and heels on the ground. Sitting at the starting line of the bench (marked at 23 cm), athletes reached forward along the measurement scale, pushing a movable bar as far as possible without bending their knees. The maximum reach was recorded after holding the position for two seconds. Each athlete performed the test twice, and the best score was used for statistical analysis.

Statistical Analysis

In this study, the SPSS (Statistical Package for the Social Sciences, Inc., Chicago, IL, USA) version 25 software was utilized for statistical analysis. Descriptive statistics of the athletes were conducted, and the Shapiro-Wilk test was employed to assess the normal distribution of the groups. A Dependent Sample T test was employed to compare the pre-test and post-test results of the athletes. The significance level was set at $p<0.05$.

Results

Table 1 presents a comprehensive comparison of the initial and final measurements for each assessed parameter, demonstrating the effects of the intervention on the athletic performance of the participants. According to the data, there was a statistically significant improvement in the flexibility, vertical jump (VJ), horizontal jump (HJ), and both left and right ankle dorsiflexion ROM measurements, with respective p-values of 0.026, 0.040, 0.040, 0.014, and 0.003. These results indicate notable enhancements in key athletic performance metrics following the intervention. Conversely, no significant differences were observed in the hip flexion ROM for both the left ($p = 0.772$) and right ($p = 0.758$) legs, suggesting that joint distraction exercises may not influence hip mobility within the parameters of this study.

Discussion

This study aimed to investigate the effects of joint distraction exercises on the lower extremities during warm-up, specifically assessing range of motion, flexibility, and jump performance in female volleyball players. The findings demonstrated statistically significant improvements in flexibility, vertical jump (VJ), horizontal jump (HJ), and ankle range of motion (ROM) for both the left and right ankles with p-values of 0.026, 0.040, 0.040, 0.014, and 0.003, respectively. While there were incremental increases observed in the left and right hip ROM (+0.49° and +0.95° respectively), these changes did not reach statistical significance ($p = 0.772$ for left hip and $p = 0.758$ for right hip).

Warming up is crucial for enhancing sports performance and reducing the risk of injuries. Various warm-up strategies, including those that involve joint distraction with elastic bands, are employed by athletes to achieve optimal performance levels and safeguard against injuries [25]. Joint distraction exercises involve applying a force that separates the joint surfaces, which can significantly improve joint mobility [26]. Although studies focusing on joint distraction with elastic bands during warm-ups are

Table 1. Comparison of Initial and Final Measurements of Athletes

Measurement	Initial Mean±SD	Final Mean±SD	p-value
Sit & Reach (cm)	30.33±8.48	32.0±7.85	0.003*
Left Leg Hip Flexion ROM (°)	76.59±5.20	77.35±5.86	0.439
Right Leg Hip Flexion ROM (°)	77.67±8.16	78.60±6.93	0.600
Left Ankle Dorsiflexion ROM (°)	47.31±7.41	49.83±8.09	0.010*
Right Ankle Dorsiflexion ROM (°)	46.77±9.39	50.10±8.84	0.000*
Vertical Jump (VJ) (cm)	30.83±5.16	32.18±4.44	0.001*
Horizontal Jump (HJ) (cm)	126.13±27.39	154.83±13.44	0.001*

limited, our findings are consistent with existing literature. We observed a significant improvement in flexibility scores from the sit-and-reach test after employing joint distraction exercises, a result that aligns with findings from other researchers who also reported significant enhancements in flexibility following similar interventions [13].

Improving the flexibility of athletes is widely acknowledged to positively impact their jump performance [27, 28]. Various studies support this relationship; for instance, researchers examining the physical performance of female athletes through traditional stretching and myofascial release found significant increases in both flexibility and jump performance [29]. Similarly, a study involving active university women reported enhancements in range of motion (ROM) and jump performance correlating with increased flexibility scores [30]. Further, dynamic stretching exercises were shown to positively affect ROM and vertical jump performances in young female artistic gymnasts [31], with another study highlighting that dynamic stretching led to improved jump performance in athletes [32].

Consistent with these findings, our study also demonstrated that joint distraction exercises significantly elevated both flexibility and jump scores among the athletes. This correlation reinforces the established notion that enhanced flexibility contributes to better jump performance, confirming the efficacy of joint distraction exercises in sports training protocols.

Limited ankle dorsiflexion range of motion (ROM) is a well-documented risk factor for injuries to the knee, ankle, shin, and hamstring in athletes [22, 33, 34]. This limitation also significantly impacts performance in sports like volleyball, where ankle joint ROM plays a crucial role [35]. Previous research has consistently shown that improvements in ROM can lead to enhanced jump performance. For instance, studies have demonstrated that athletes using elastic bands to increase their ROM scores see corresponding improvements in power performance [37, 38]. Driller and Overmayer [39] specifically noted that increases in ankle dorsiflexion angles were directly associated with higher vertical and long jump performances. Similarly, other studies have established a positive correlation between increased ankle mobility and enhanced vertical and horizontal jump capabilities [40, 41, 42]. Additionally, reduced vertical jump performance has been linked to low levels of ankle ROM [43].

The findings of our study corroborate these observations, reinforcing the critical role of enhanced ankle dorsiflexion ROM in improving jump performance and reducing injury risks among volleyball players. Our results confirm that joint distraction exercises effectively increase ROM and subsequently enhance athletic performance, aligning with the broader research landscape.

Elastic bands are increasingly favored in resistance training due to their provision of variable resistance loads, which can yield superior results in developing power, strength, and speed compared to traditional free weights [44]. Elastic band training has been utilized to increase muscle strength through enhanced range of motion (ROM) [45]. For instance, research involving 17 male bodybuilding athletes demonstrated that four joint distraction exercises using elastic bands during warm-ups significantly improved maximum repetition (1RM) squat performance [14]. Furthermore, studies suggest that exercises performed over a wider range of motion can offer greater benefits in terms of muscle strength and hypertrophy, linking increased ROM to muscle growth [46].

The application of proprioceptive neuromuscular facilitation (PNF) exercises with elastic bands has also shown significant health benefits. In patients with ankle instability, these exercises led to notable improvements in balance and muscle strength [47]. A 12-week intervention with elderly individuals using elastic bands resulted in enhanced joint ROM and muscle strength, suggesting that these exercises can effectively support aging populations [10]. Moreover, it has been reported that regular exercise with elastic bands can boost the quality of life in the elderly by positively impacting balance, endurance, and agility [48].

Notably, exercises using elastic bands have been found to improve jump performance more effectively than traditional training methods [49]. Additionally, a study using PNF exercises with elastic bands observed increases in strength and speed, further confirming the broad utility and efficacy of elastic bands in training [50].

These findings align well with the results of our study, which also observed improvements in flexibility, ROM, and jump performance through the use of joint distraction exercises with elastic bands in female volleyball players.

Athletes often employ various stretching methods prior to exercise, each of which must be carefully chosen based on timing and specific objectives [6]. Historically, research has demonstrated that static stretching performed before exercise might impair athletic performance, rather than enhance it [51, 52, 53, 54]. In contrast, dynamic stretching is generally recommended as it not only helps protect against sports injuries but also tends to improve overall sports performance. For example, a study involving artistic gymnastics athletes found that dynamic stretching notably increased both jump performance and ROM scores [31]. This supports the notion that dynamic stretching is particularly effective in enhancing ROM values among athletes [36].

Further, it has been observed that while static stretching does not lead to improvements in jump

performance, dynamic stretching has a positive impact [32]. Beyond static and dynamic stretching, self-myofascial release has also been shown to contribute to performance enhancements [13]. These findings suggest a complex relationship between the type of stretching used and the outcomes on athletic performance, emphasizing the need for carefully selected warm-up routines that include methods such as dynamic stretching or self-myofascial release to optimize performance effectively.

The review of literature indicates that diverse methods are employed during warm-ups to enhance performance and prevent injuries. The use of elastic bands is particularly prevalent across various sports disciplines. However, studies focusing specifically on joint distraction using elastic bands are relatively scarce [13, 14]. In our study, the application of joint distraction exercises with elastic bands led to significant improvements in sit-reach flexibility scores, ankle dorsiflexion ROM, as well as vertical and horizontal jump performances. It appears that the enhancements in jump performance can be attributed to the increased flexibility and ROM facilitated by these exercises. Given these results, incorporating joint distraction exercises with elastic bands into training routines and pre-competition warm-ups could be highly beneficial for athletes, potentially serving as a valuable tool for coaches aiming to optimize athletic performance.

The promising results of our study demonstrate the potential of joint distraction exercises with elastic bands in enhancing ROM, flexibility, and jump performance. Future studies should explore the long-term effects of these exercises on athletic performance and recovery, and how they compare with other flexibility and strength training modalities. Investigating the physiological mechanisms behind the improvements observed could lead to better tailored training protocols for various sports disciplines.

Conclusions

This study has established that joint distraction exercises with elastic bands significantly improve range of motion, flexibility, and jump performance in athletes. These findings highlight the exercises' potential benefits, particularly for athletes looking to enhance these specific performance areas. However, the study's limitations include its focus solely on female athletes and its examination of only the acute effects of the exercises. The impact on male athletes remains unexplored, and the differences between acute and chronic applications are yet to be understood. Expanding the demographic scope of future studies and exploring varied application durations could further validate and deepen the impact of joint distraction exercises.

Funding

This work was supported by the Kocaeli University Scientific Research Projects Coordination Unit under grant number #3341.

Conflict of Interest

The authors declare no conflicts of interest. The funders did not participate in the design of the study; nor in the collection, analysis, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

Acknowledgment

We extend our gratitude to Mr. Erhan Er for his support of our study.

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Cite this article as:

Taş B, Ok E, Akalp U, Bingül BM, Gelen E. Effect of lower extremity joint distraction exercises during warm-up on range of motion, flexibility, and jump performance in female volleyball players. *Pedagogy of Physical Culture and Sports,* 2024;28(4):283–291.
https://doi.org/10.15561/26649837.2024.0405

Received: 30.03.2024
Accepted: 09.06.2024; Published: 30.08.2024