PHYSICAL EDUCATION OF STUDENTS

ORIGINAL ARTICLE

Acute effect of joint distraction exercises used in warm-up on jumping in volleyball players

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Abstract

Background and Study Aim: Jump performance is a common component of volleyball, as it contributes to both offensive and defensive actions. Explosive lower-limb strength is regularly developed and maintained in training and match preparation. Although various warm-up methods are applied to enhance jump performance, their relative effectiveness remains a subject of practical interest. The purpose of this study was to examine the acute effects of joint distraction exercises incorporated during warm-up on jump performance in volleyball players.

Material and Methods: The study involved 12 female and 11 male volleyball players from Alanya Alaaddin Keykubat University, who participated voluntarily. A convenience sampling method was used. Anthropometric data (height, weight, age) were collected, and jump performance was assessed with the *My Jump 2* mobile application, a validated tool for measuring squat jump (SJ) and countermovement jump (CMJ). The testing protocol included a general warm-up, followed by joint distraction exercises using resistance bands applied to the ankle, hip, and shoulder joints. Jump performance was measured both after the general warm-up and following the joint distraction protocol. Data analysis was performed with IBM SPSS Statistics 25.0. As the sample size was below 50, normality was checked with the Shapiro–Wilk test. Because some data did not follow a normal distribution, the Wilcoxon signed-rank test was applied, with the level of significance set at $p<.05$.

Results: Statistically significant differences were observed in female athletes across all measured SJ and CMJ parameters, including height, flight time, strength, power, and speed (p values ranging from .00 to .02). In male athletes, improvements were more specific, with significant differences in SJ strength and power ($p=.04$) and in CMJ parameters (height, flight time, strength, power, speed; p values ranging from .00 to .01). These results indicate that joint distraction exercises produced a broader acute effect in females, while in males the improvements were more concentrated in strength- and power-related variables.

Conclusions: Joint distraction exercises incorporated into warm-up routines can be regarded as a practical approach within volleyball training and rehabilitation contexts, providing applicable insights for coaches and clinicians.

Keywords: volleyball, warm-up, joint distraction, squat jump (SJ), counter movement jump (CMJ).

Introduction

Volleyball is a sport that involves frequent explosive movements, including jumping, sprinting, and rapid changes of direction. Vertical jump ability is one of the main components that contribute to both attacking and defensive actions. The effectiveness of these movements depends on the coordinated function of the neuromuscular system, with lower-limb strength and power influencing the quality of explosive actions. At the same time, jump performance is affected by several factors such as warm-up strategies, fatigue, technical skills, and individual physical characteristics of the players.

Volleyball is played for short durations, with alternating periods of rest and load, and involves biomotor parameters such as speed, jumping, agility, muscle strength, and aerobic fitness performed at high intensities over relatively short intervals [1]. Since volleyball performance is strongly linked to explosive movements, the ability to maintain high jumping capacity becomes essential during the game. Vertical jumping is not only a frequent activity but also a decisive element in technical actions such as spikes and blocks, and elite volleyball players can perform as many as 150 jumps during a single

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match, which illustrates the physical demands associated with repeated jumping [2–4]. Because of this high frequency, accurate assessment tools are required to monitor players' readiness and physical condition. Vertical jump testing is widely applied because it provides valuable information about an athlete's anaerobic power, with jump height being regarded as the primary indicator for assessing anaerobic capacity [5].

Within this framework, the countermovement jump (CMJ) is particularly useful, as it enables monitoring of both acute and long-term changes in performance and provides insight into lower-limb strength. Its effectiveness lies in its reflection of the stretch-shortening cycle, a mechanism involving eccentric and concentric muscle contractions that operates across many sports [1, 6]. Nevertheless, CMJ outcomes are not determined by muscle power alone, as many physiological and biomechanical factors can affect performance. Panoutsakopoulos and Bassa reported that ankle flexibility and knee extensor torque were significantly associated with CMJ height in female volleyball players [7]. In this context, vertical jumping is a multifactorial performance indicator in volleyball, influenced by both muscular and biomechanical characteristics, and serves as a practical measure of explosive capacity.

Since warm-up routines directly affect neuromuscular readiness, they represent one of the external factors that can modify jump performance. The beneficial effects of warm-up on performance are well established, particularly for high-intensity skills such as countermovement vertical jumps [8]. Designing an effective warm-up requires attention to multiple parameters and variables, and this complexity makes it difficult to define a single ideal approach suitable for all sports [9]. Warm-up routines can be categorized according to their purpose and content. General warm-ups include non-specific physical activities such as jogging, skipping, or light stretching. Conditioning-based warm-ups emphasize the development of strength and flexibility. Ludic warm-ups incorporate playful elements to reduce monotony. Sport-specific warm-ups involve activities related to the sport itself but not directly aligned with the objectives of the main session or competition. Finally, session-specific warm-ups are tailored not only to the sport but also to the exact demands of the upcoming training session [10]. The inclusion of stretching exercises within a warm-up routine is considered to be one possible method of enhancing performance [11].

Since warm-up routines are closely connected to joint mobility and neuromuscular readiness, one particular approach that has gained attention is the use of joint distraction exercises. Ottenhoff et al. reported that joint distraction can reduce pain and improve physical function [12]. This method is recognized as both a treatment and training technique with a role in orthopaedics and rehabilitation. Beyond traditional approaches, joint distraction aims to enhance functional capacity by reducing the load on joints and increasing mobility. It is frequently applied to individuals with sports injuries and joint diseases and has gained more prominence in the literature in recent years [13, 14].

To maximize its benefits, joint distraction is often combined with exercise programmes that target the musculoskeletal system. Evidence suggests that applying joint distraction during the warm-up phase can improve flexibility and jump performance, particularly among athletes [14]. At the same time, research has shown that this method is effective in osteoarthritis and may also contribute to the management of degenerative joint diseases [15, 16].

Clinical findings further expand the relevance of this technique. Studies indicate that joint distraction can lead to structural and clinical improvements in conditions such as haemophilic ankle arthritis [17]. These observations underline that understanding its mechanisms is valuable not only for athlete rehabilitation but also for the broader management of sports-related injuries [18, 19].

Analysis of research findings has shown that vertical jump ability is closely linked to both performance outcomes in volleyball and broader aspects of musculoskeletal function. Researchers emphasize that warm-up strategies, including joint distraction exercises, can influence neuromuscular readiness, flexibility, and jump efficiency, while also having applications in rehabilitation and joint health. Despite these established benefits, the way joint distraction affects acute performance parameters in volleyball players remains a subject of practical consideration. This provides the basis for further examination of how such exercises may be integrated into warm-up routines to optimize athletic performance.

Drawing on existing evidence, it may be proposed that joint distraction exercises performed during warm-up influence jumping performance in volleyball players. Accordingly, the following hypothesis was formulated: joint distraction exercises incorporated into warm-up routines exert an acute effect on jumping performance in volleyball players. Consistent with this hypothesis, the purpose of this study was to examine the acute effects of joint distraction exercises applied during warm-up on jump performance in volleyball players.

Materials and Methods

Participants

A convenience sampling method was employed in this study. Convenience sampling is a non-random approach in which the sample

is determined by the researcher's judgment [20]. According to Kinnear and Taylor, the use of this method in practice accounts for approximately 53% of studies [21]. The sample consisted of 12 female volleyball players from the women's team and 11 male volleyball players from the men's team at Alanya Alaaddin Keykubat University. Participation in the study was voluntary. The study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Non-Interventional Clinical Research Ethics Committee of Alanya Alaaddin Keykubat University (2024/02; 14.05.2024).

Research Design

Anthropometric Measurement and Strength Tests

Height: Measurements were taken barefoot, with the head in an erect position aligned to the Frankfort plane. The stadiometer was placed at the vertex of the head. After a deep inspiration, the distance between the vertex and the sole of the foot was measured and recorded in centimeters using a Seca stadiometer.

Weight. Athletes wore standard sports clothing (t-shirt and shorts) during measurement. Body mass was recorded in kilograms using a Tanita BC 418 electronic scale with an error margin of 100 g.

Vertical Jump Test. Vertical jump performance was assessed using the My Jump 2 application for iPhone, a validated and reliable measurement tool. Bogataj et al. conducted a study confirming its validity and reliability [22]. My Jump 2 is a low-cost, user-friendly, and practical instrument that enables practitioners and coaches to monitor physical fitness through reliable assessments of jumping ability, including the Squat Jump (SJ) and Countermovement Jump (CMJ).

Squat Jump Test. The squat jump test evaluates explosive strength of the leg muscles based on maximal force output. Participants performed maximal vertical jumps from a squat position with knees flexed at 90 degrees and hands placed on the waist. Each measurement was repeated three times, and the highest representative value was recorded [23]. A two-minute rest period was provided between trials.

Countermovement Jump Test. The CMJ began from a standing position with the torso upright, knees extended, and feet shoulder-width apart. Participants were asked to keep their hands on their hips throughout the test. They performed a rapid downward movement (approximately 90° knee flexion) followed immediately by an upward movement to achieve maximum jump height [22].

Warming and Exercise Protocol

A vertical jump test was administered following the general warm-up during the first training session of the experimental group. In the subsequent training session, held two days later, athletes performed an additional protocol that included five exercises targeting the ankle, hip, and shoulder joints with the use of resistance bands. The exercises were performed in two sets for both the right and left sides, each lasting 30 seconds per side. All exercises were executed consecutively without rest during set intervals or transitions between movements. Two minutes after the completion of the exercises, vertical jump tests were conducted. Figure 1 illustrates the execution of the exercises.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics version 25.0 for Windows. Descriptive statistics included percentage, frequency, arithmetic mean, standard deviation, and median. Since the sample

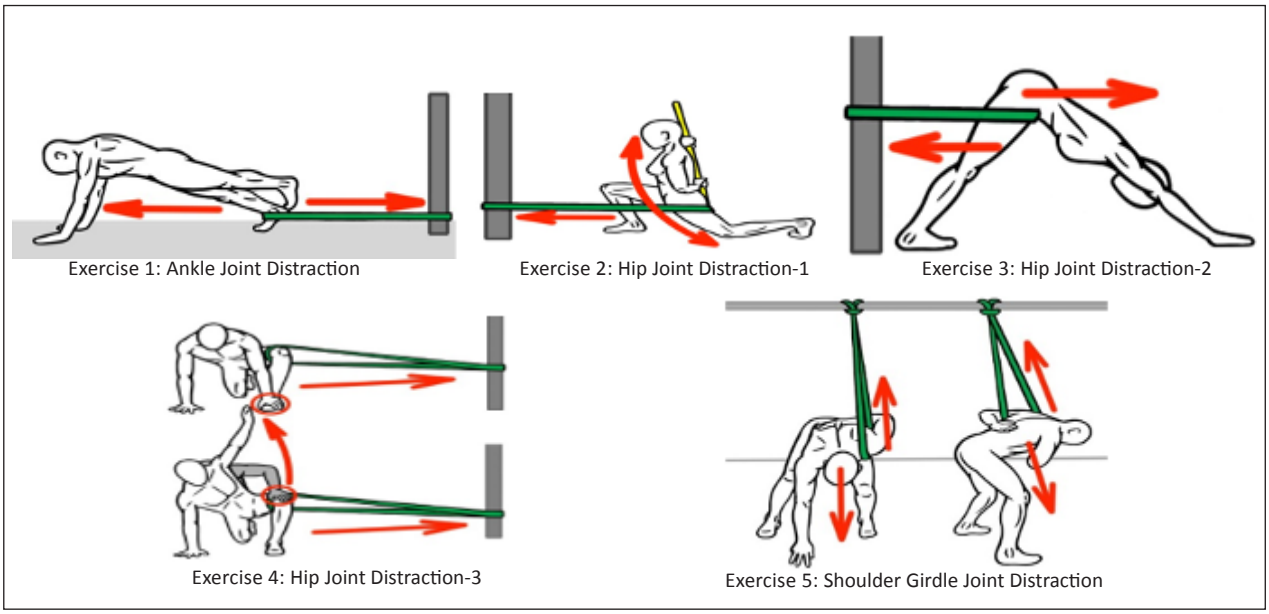

Figure 1. Exercises of Joint Distraction [23]

size was below 50, the Shapiro–Wilk test was applied to assess the normality of the data distribution [25]. The results indicated that some variables followed a normal distribution, while others did not. Considering the small sample size [26], the Wilcoxon signed-rank test was employed as a nonparametric method. The level of significance was set at $p<.05$.

Results

The descriptive characteristics of the participants and the outcomes of the Wilcoxon signed-rank test are presented below. Table 1 summarizes the age, weight, and height values for the female and male volleyball players included in the study.

The results indicate that both female and male participants were young adult athletes with relatively homogeneous age distribution. Female players presented lower body mass and height values compared to their male counterparts, while age characteristics were similar between groups.

Table 2 presents the Wilcoxon signed-rank test results for female and male athletes, comparing pre-test and post-test values of squat jump (SJ) and countermovement jump (CMJ) performance parameters.

Analysis of the results shows that female athletes demonstrated significant improvements in all SJ and CMJ parameters, indicating a broad acute effect of joint distraction exercises. In contrast, male athletes exhibited significant differences in SJ strength and power and across CMJ parameters, suggesting a more pronounced effect in countermovement performance than in squat jump outcomes.

Discussion

The purpose of this study was to examine the acute effects of joint distraction exercises, applied during warm-up, on jump performance in volleyball players. The main findings demonstrated that female athletes showed significant improvements across all measured parameters of both squat jump (SJ) and countermovement jump (CMJ), while male athletes displayed significant improvements primarily in SJ strength and power and in all CMJ parameters. These results suggest that joint distraction exercises may contribute to enhanced jump-related performance, with more consistent effects observed in female players.

The positive effects of joint distraction on sports performance are consistent with findings from previous research. Taş et al. reported that joint distraction exercises during warm-up improved flexibility and jump performance in female volleyball players [14]. Similarly, Çağlın et al. observed that joint distraction exercises with elastic bands had a positive impact on maximum power performance in male bodybuilding athletes [27].

In the present study, significant improvements were recorded in both female and male volleyball players following a single session of joint distraction warm-up, although with different patterns. Among females, all measured parameters improved, including SJ and CMJ height, flight time, strength, power, and speed. This suggests that joint distraction exercises may enhance neuromuscular readiness more efficiently in female athletes. Previous studies support this observation, indicating that

Table 1. Age, weight, and height data of the study group

Sex	Variable	N	Min	Max	Mean	SD
Female	Age (years)	12	19.0	24.0	20.58	1.37
	Weight (kg)	12	51.0	69.0	61.16	4.82
	Height (cm)	12	168.0	180.0	174.41	4.33
Male	Age (years)	11	19.0	22.0	20.54	1.12
	Weight (kg)	11	74.0	105.0	81.18	9.20
	Height (cm)	11	178.0	196.0	185.18	6.32

Table 2. Wilcoxon test statistics for female and male athletes

Sex	SJH2 - SJH1	SJFT2 - SJFT1	SJSt2 - SJSt1	SJP2 - SJP1	SJSp2 - SJSp1	CMJH2 - CMJH1	CMJFT2 - CMJFT1	CMJSt2 - CMJSt1	CMJP2 - CMJP1	CMJSp2 - CMJSp1
Female (Z)	-2.375b	-2.264b	-2.201b	-2.201b	-2.414b	-2.842b	-2.873b	-2.805b	-2.805b	-2.913b
Female (p)	.018*	.024*	.028*	.028*	.016*	.004*	.004*	.005*	.005*	.004*
Male (Z)	-1.787b	-1.807b	-1.992b	-1.992b	-1.725b	-2.527b	-2.555b	-2.521b	-2.521b	-2.555b
Male (p)	.074	.071	.046*	.046*	.084	.012*	.011*	.012*	.012*	.011*

Note. a = Wilcoxon signed-rank test; b = based on negative ranks; SJ = Squat Jump; CMJ = Countermovement Jump; H = Height; FT = Flight Time; St = Strength; P = Power; Sp = Speed; 1 = pre-test; 2 = post-test; * = $p < .05$.

females may show greater acute responsiveness to proprioceptive and mobility-oriented interventions [14, 27].

In contrast, improvements in the male group were more concentrated on strength- and power-related variables, such as CMJ height, flight time, strength, and power. Although the effects were less comprehensive than those observed in the female group, the results still demonstrate that male participants benefited from joint distraction protocols in terms of explosive performance.

On the other hand, studies have also shown that joint distraction can provide both clinical and structural improvements. Van Meegeren et al. examined the clinical outcomes of joint distraction in three patients with haemophilic ankle arthritis and reported improvements in their condition [17]. Lee et al. demonstrated that patients with advanced lateral osteoarthritis were able to return to sports and work life following joint distraction [13]. In addition, Haelewijn et al. reported that ankle joint distraction applied to an adolescent patient with hemophilia resulted not only in structural improvements but also in functional gains [28]. Taken together, these findings highlight the positive effects of joint distraction not only on athletic performance but also on overall quality of life.

However, further research is required to clarify the effects of joint distraction. Fridén et al. examined variations in injury patterns in ACL-injured knees exposed to compression versus distraction forces in contact sports and skiing, emphasizing the biomechanical importance of different loading types [18]. Their findings suggest that joint distraction interventions may influence tissue strain and injury mechanisms. Complementary to this, Werner et al. quantified shoulder distraction forces in professional baseball pitchers, reporting average peak loads of 947 ± 162 N – data that are essential for understanding soft-tissue adaptation and injury risk in overhead athletes [19]. These results indicate that joint distraction during warm-up could modulate mechanical loading patterns and potentially contribute to injury prevention. Nevertheless, a study conducted by the Norwegian Football Association [29] reported that a comprehensive warm-up program, which included joint distraction exercises, did not significantly reduce injury risk in young football players.

Dynamic warm-up strategies, including joint distraction, have been shown to enhance muscle–tendon unit readiness and explosive performance without the flexibility reductions commonly associated with static stretching. Esteban-García et al. reported that dynamic stretching improves vertical jump height and range of motion (ROM) [30]. In a similar vein, integrative protocols that combine active mobilization with activation phases have demonstrated significant improvements in joint ROM and functional capacity [31]. The underlying mechanisms of joint distraction exercises are likely related to increased synovial fluid redistribution, decreased joint resistance, enhanced proprioceptive feedback, and post-activation potentiation.

Moreover, gender-specific adaptations and responses to different warm-up modalities remain an important avenue for exploration. In this context, the findings of Pleša et al. are particularly relevant, as they demonstrated strong correlations between RSImod values obtained from bilateral CMJ and approach jump height in volleyball players [32]. Their work emphasizes the importance of applying reactive strength indices to capture neuromuscular performance characteristics more comprehensively, which may also complement EMG-based assessments in future investigations.

The present study demonstrated that joint distraction exercises, when incorporated into warm-up routines, produced acute improvements in jump-related performance parameters among volleyball players, with more consistent effects in females than in males. These results suggest that joint distraction may serve as a practical strategy to enhance neuromuscular readiness and explosive performance in volleyball.

Limitations and Future Research

This study was limited by its relatively small sample size and short-term design, which restricts the generalizability of the findings. Future studies should incorporate EMG analyses to explore neuromuscular activation patterns in greater depth and should employ long-term randomized controlled trials to assess the chronic benefits and injury-prevention potential of joint distraction interventions. Further investigations are also needed to examine how athletes from different sports can apply joint distraction exercises more effectively to reduce injury risk and improve performance. Such research will contribute to a more comprehensive understanding of how joint distraction can support both performance enhancement and joint health maintenance.

Conclusions

Joint distraction exercises, when incorporated into warm-up routines, represent a practical approach within sports practice and rehabilitation. Their use may be considered in designing warm-up protocols for volleyball and other athletic contexts, providing applicable guidance for coaches and clinicians.

Conflict of Interest

The authors declare no conflict of interest.

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