ANKLE MOBILITY PROFILE OF VOLLEYBALL PLAYERS: DOES PLAYING POSITION MATTER?

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Abstract:

This study establishes reference values for ankle joint mobility and lower extremity asymmetry in elite female volleyball players (N=146), analyzing the specific impact of playing position. Dorsiflexion range of motion was measured bilaterally using a digital goniometer. A one-way ANOVA revealed that playing position had no statistically significant effect on ankle mobility ($F_{[4,141]}=0.174$, $p=0.952$). However, the results indicated significant lateral dominance, with greater mobility in the right ankle compared to the left ($t=5.180$, $p<0.001$, $d=0.429$). Mean asymmetry ranged from 9.6% in setters to 11.9% in liberos. It is concluded that the observed asymmetry (up to 12%) represents a sport-specific functional adaptation rather than a pathological deficit. Training protocols should utilize these population-specific norms, focusing on safe force absorption during landing rather than strictly insisting on perfect bilateral symmetry.

Keywords:

Biomechanics, Asymmetry, Range of Motion, Injury Prevention, Female Athletes.

INTRODUCTION

Volleyball ranks as one of the most widely played sports among women, with athletes competing at numerous levels across various age groups [1]. Unlike some other team sports, volleyball is distinguished by its clearly defined playing positions - such as setter, libero, middle blockers, opposite hitter, and outside hitter, each with specific responsibilities that contribute to the team's overall strategy during the game [2]. These roles not only structure the game but also require athletes to develop unique skill sets tailored to their positional demands.

Of particular note are two specialized roles: the libero, whose primary focus is defensive execution, and the setter, who manages tactical ball distribution during offensive sequences. On the other hand, positions engaged in attacking and blocking differ not only in their approach to offensive maneuvers but also in the frequency and the intensity of jumps performed during the game [2].

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Given these positional and task-related variations, a comprehensive biomechanical analysis is essential for enhancing performance efficiency and minimizing injury risk among volleyball players [3, 4, 5]. Basic stances adopted by volleyball athletes predominantly involve squat mechanics, making adequate ankle joint mobility a critical prerequisite for effective movement patterns. Moreover, volleyball demands repeated jumping activities executed bilaterally as well as single-leg takeoffs [6].

As a result, landings typically occur unilaterally or bilaterally, often with a greater load on one leg [6, 7]. Therefore, there is a significant need to establish clear and standardized values for this population. The existing literature should offer reference standards for acceptable ankle joint mobility and asymmetries, which would serve as threshold values for identifying compensatory movement patterns [3]. When individual measurements fall below these established norms, the risk of injury may be substantially increased. Current research reveals a lack of such standardized values for professional female volleyball players. Accordingly, the present study aims to address this gap by examining ankle mobility within this specific cohort, providing data and practical guidance for training protocols and injury prevention strategies. Additionally, it is essential to highlight that establishing standardized measurement procedures via digital goniometers is a methodological necessity, as it guarantees the accuracy, reliability, and efficient processing of the collected data.

2. METHODS

2.1. PARTICIPANTS

A total of 146 professional female volleyball athletes volunteered to participate in this study, distributed as follows: n=21 setters, n=19 opposite hitters, n=22 liberos, n=50 outside hitters, and n=34 middle blockers. The anthropometric characteristics corresponding to each of the five playing positions are reported in Table 1. All participants were members of their respective professional volleyball teams competing in top level league (e.g., SuperLeague) and had been cleared of any musculoskeletal injuries that might have compromised or impeded testing procedures. The protocol was reviewed and approved by the University's Institutional Review Board, and written informed consent was obtained from all athletes prior to data collection.

2.2. PROCEDURES

After completing a standardized dynamic warm-up protocol consisting of dynamic stretching exercises (e.g., A-skip, B-skip, side-to-side lunge, high-knees, cross-step) and low-intensity volleyball-specific drills lasting 10–15 minutes, athletes underwent an ankle range of motion (ROM) assessment using a digital goniometer (K-Move, Kinvent, Montpellier, France). Participants assumed a lunge stance facing a wall, keeping the tested foot flat on the floor and the opposite leg positioned behind for support (in high kneeling split stance). The device was fixed to the dorsal aspect of the foot and the anterior tibia and calibrated from the upright starting position. Athletes were instructed to slowly move their knee toward the wall while ensuring continuous heel contact until they reached maximum pain-free dorsiflexion. The digital goniometer automatically recorded the joint angle during this maneuver. Each athlete completed two trials per limb, and the mean value across both limbs was calculated to serve as the representative ankle ROM measure for performance analysis. Furthermore, inter-limb asymmetry (ASYM) was determined as the absolute difference in ROM between the left and right ankles [8, 9].

2.3. STATISTICAL ANALYSIS

Data analysis was conducted using SPSS (Version 26.0; IBM Corp., Armonk, NY), a professional statistical software package. Descriptive statistics - including means ($\bar{x}$), standard deviations (SD), minimum, and maximum values - were calculated for each dependent

Table 1. Anthropometric profiles of participants, categorized by playing position

Playing position	Age [years]	Body mass [kg]	Height [cm]
Setter	22.2±4.0	70.5±8.5	179.3±3.8
Opposite hitter	21.2±4.0	79.0±10.8	187.9±4.2
Libero	20.4±3.6	65.2±7.5	171.1±4.7
Outside hitter	19.9±4.7	72.5±6.2	183.5±3.9
Middle blocker	21.1±4.5	73.5±6.0	186.7±3.2

variable and are presented in Table 2. The Shapiro-Wilk test was employed to assess the normality of data distribution, while homogeneity of variances was evaluated using Levene's test. Cohen's d effect sizes were calculated to assess the magnitude of differences across all variables and were interpreted as trivial (<0.20), small (0.20–0.49), moderate (0.50–0.79), or large (≥0.80) [10].

Differences in ankle mobility between left and right legs were examined using a paired samples t-test. In addition, to examine the effect of playing position on ankle ROM, a one-way analysis of variance (ANOVA) was performed.

3. RESULTS

Descriptive statistics, such as means and standard deviations (x±SD), as well as minimum and maximum values for each dependent variable evaluated in this study, are presented in Table 2. These statistics provide a comprehensive overview of the data distribution and variability among the different playing positions. As shown in Table 2, the middle blockers exhibited the highest average ankle mobility for the right limb, with a mean value of 44.3°.

Table 2. Descriptive statistics of ankle mobility and asymmetry across each playing position

Statistic	Setter	Opposite Hitter	Libero	Outside Hitter	Middle Blocker
N	21	19	22	50	34
Ankle Mobility Angle Right (°)					
Mean	43.9	42.1	43.6	44.2	44.3
Std. Dev.	5.8	8.9	8.6	6.7	6.8
Min.	33.9	28.7	26.9	28.5	28.1
Max.	58.4	56.8	59.3	56.1	61.3
Ankle Mobility Angle Right (°)					
Mean	42.9	40.1	42.4	42.3	41.4
Std. Dev.	5.5	8.1	6.0	6.6	6.4
Min.	31.5	28.4	30.1	25.8	26.6
Max.	55.5	52.5	52.8	55.2	51.3
Asymmetry (%)					
Mean	9.6	10.5	11.9	10.1	10.2
Std. Dev.	6.4	6.3	5.5	5.7	7.4
Min.	2.2	1.1	4.2	0.0	0.0
Max.	23.9	24.7	25.0	31.4	26.5

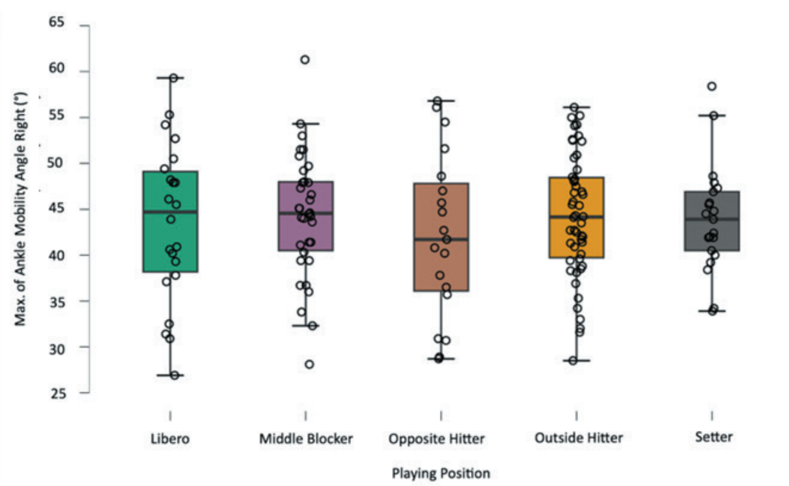

Figure 1. Graphical representation of maximal ankle mobility (°) for the right leg of professional female volleyball players

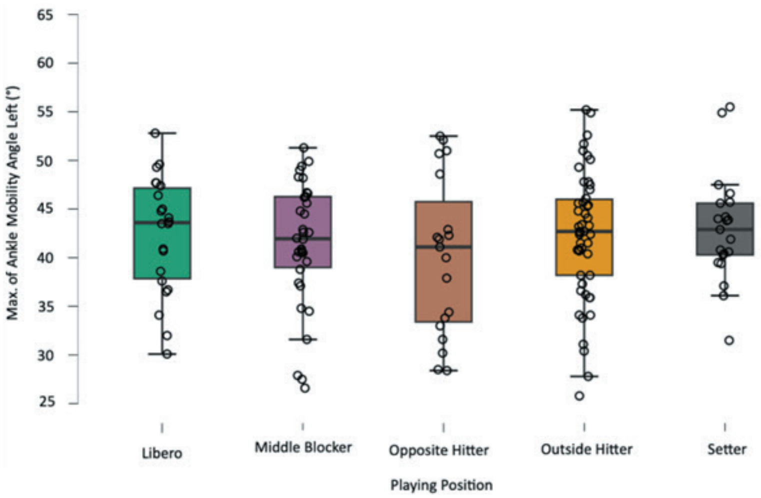

Figure 2. Graphical representation of maximal ankle mobility (°) for the left leg of professional female volleyball players

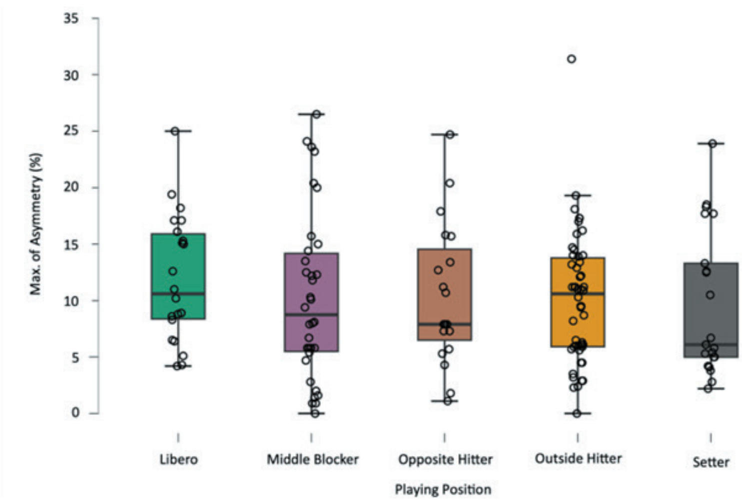

Figure 3. Graphical representation of maximal ankle asymmetry (%) for the right and left leg of professional female volleyball players

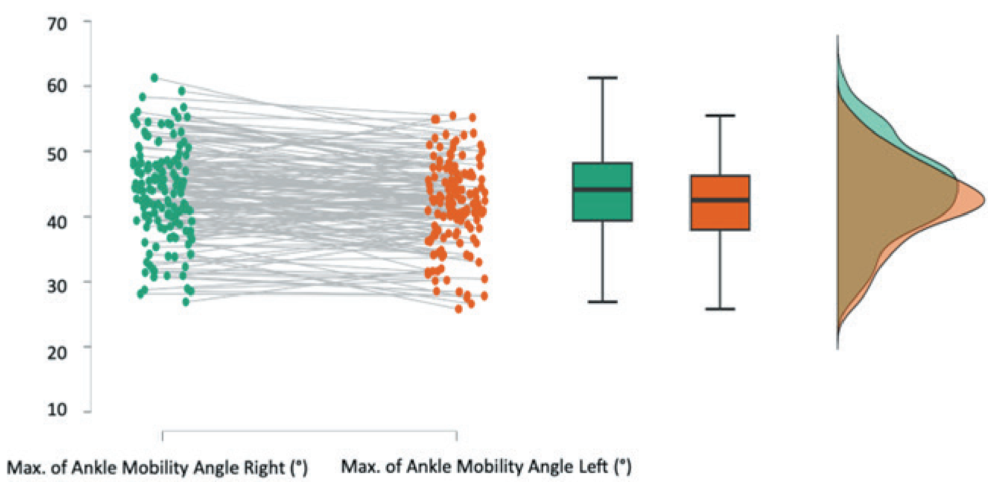

Figure 4. Graphical representation of mean ankle dorsiflexion asymmetry (%) across different playing positions in professional female volleyball playerss

In contrast, the opposite hitters recorded the lowest mean right limb ankle mobility at 42.0°. Regarding the left limb, setters showed the highest mean ankle mobility (42.9°), while opposite hitters had the lowest mean value (40.1°). When examining asymmetry, the libero position displayed the highest mean asymmetry at 11.9%, whereas the lowest mean asymmetry value was also observed in the setter position at 9.6%. These findings highlight the variation in ankle mobility and asymmetry across different volleyball playing positions.

A paired samples t-test was performed to assess differences in ankle mobility between the right and left ankle. The results indicated a statistically significant difference (t=5.180, p<0.001, d=0.429), with the right ankle exhibiting a greater range of motion than the left. This asymmetry represents a small to moderate effect size, further supporting a consistent pattern of lateral dominance among professional female volleyball players.

The one-way ANOVA revealed no statistically significant effect of playing position on ankle range of motion ($F_{[4, 141]}$=0.174, p=0.952), indicating that mobility levels were consistent across all analyzed positions.

4. DISCUSSION

The objective of this research arises from the necessity to establish clear normative values for a specific body segment that not only affects postural status but also significantly influences dynamic movement patterns [11]. Specifically, the projection of ground reaction force from distal to proximal regions highlights ankle joint mobility as fundamental to effective control of these forces. Volleyball, which emphasizes physical activities such as jumping, change of direction, and intensive movement maneuvers, inherently requires sufficient ankle mobility. Existing literature has defined normative ranges for ankle joint movement between 40° and 42° [12]; however, it remains essential to determine normative values tailored to populations like volleyball athletes and to establish reference values for asymmetries between the left and right ankle joints.

In the present study, the minimum measured values for ankle joint mobility were 40.1° for the left ankle and 42.0° for the right ankle among athletes occupying the opposite hitter position. These findings are consistent with the normative ranges reported for the general population, as established by Tourillon et al. [12]. The ability to sustain ankle mobility within these normative values is crucial for elite volleyball players, since it directly supports the physical demands of competitive play and intensive training sessions [13]. Further analysis across different volleyball positions highlights that the highest average ankle mobility was found in the right leg of middle blockers (44.3°) and in the left leg of setters (42.9). This positional variability, combined with the observed inter-limb differences, likely reflects the unilateral and repetitive demands of volleyball-specific actions such as approach, take-off, and landing.

Notably, most players in this sample predominantly use their right hand during play, which influences the function and mechanics of the lower limbs. The right leg, particularly during the execution of a planting step, plays a key role in lowering the athlete's center of mass for optimal energy accumulation [14]. This movement pattern demands increased mobility in the right ankle, further underscoring the importance of targeted mobility development in volleyball training. In accordance with the above, the left leg serves to stop forward movement and direct upwards by placing the foot at an angle [15]. Thus, the left leg must absorb greater forces to redirect the force from a horizontal to a vertical trajectory, which leads to increased exposure of the left leg's musculoskeletal system. As a result, the optimal angle for transforming this force is crucial for efficient movement, as explained by Coleman and Lobietti [16]. The same authors highlight that volleyball players predominantly land on their left foot, with ground reaction forces during these landings reaching up to six times body weight (6 BW) [16]. This observation calls attention to biomechanical differences between the legs, supporting the notion that the left leg plays a dominant role in absorbing large forces during both jumping and landing phases. Overall, these factors contribute to observed inconsistencies in ankle mobility and reinforce the importance of the left leg in managing high-impact actions in volleyball.

Consequently, the position-specific asymmetries observed in this study hold significant clinical and practical value. With mean asymmetry values ranging from 9.6% in setters to 11.9% in liberos, our findings strongly advocate for the establishment of population-specific normative data. While clinical thresholds traditionally flag asymmetries above 10% as risk factors for lower extremity injuries, such generalized metrics must be interpreted cautiously in elite athletic cohorts [17]. The observed asymmetries likely reflect functional, sport-specific adaptations rather than pathological deficits, highlighting that generalized standardized values can be profoundly misleading when applied to top-level volleyball players.

From a practical perspective, mitigating injury risk requires both an understanding of functional asymmetries and the application of targeted interventions [18]. This approach encompasses managing training loads that exacerbate these asymmetries (such as the amount of jump serves and attacks), alongside implementing preventive strategies to reduce their impact. Additionally, careful consideration should be given to the use of bilateral exercises with external resistance, considering that full range of motion in those motions can influence undesirable compensatory patterns. Strength and conditioning coaches should account for these natural functional asymmetries (up to 12%) rather than strictly attempting to correct them to a perfect 0%. Training should focus on left ankle dorsiflexion mobility to safely absorb high landing forces (up to 6 BW), incorporating unilateral eccentric exercises [16].

5. CONCLUSION

This study demonstrates the necessity of establishing normative values for distinct populations and defining asymmetry standards between the left and right sides of the body. The findings indicate that top volleyball athletes exhibit average maximum values that surpass those previously documented in the literature [1, 12]. Developing such standards represents a critical initial step toward comprehending the sport's physical requirements and formulating guidelines for return-to-training and competition following ankle injuries.

While defining normative data is a critical first step, future studies should focus on longitudinal tracking of ankle mobility across the competitive season. Utilizing standardized digital goniometry, researchers can monitor how these values fluctuate in response to varying weekly training loads. Such longitudinal data will offer a deeper understanding of sport-specific adaptive processes, ultimately clarifying how dynamic ankle function contributes to overall movement sequencing and the mitigation of lower extremity injuries.

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