ISOMETRIC STRENGTH DIFFERENCES IN THE ATHLETIC SHOULDER TEST IN FEMALE VOLLEYBALL PLAYERS

Damjana V. Čabarkapa[1]*,
[0000-0003-4680-0313]
Vladimir Banković[1],
[0009-0000-5133-4383]
Nenad Trunić[1],
[0000-0001-5339-7695]
Dimitrije Čabarkapa[2]
[0000-0001-9912-3251]

[1]Singidunum University,
Belgrade, Serbia

[2]University of Kansas,
Lawrence, USA

Abstract:

Volleyball is a sport that requires both lower- and upper-body power, particularly during explosive actions such as attacking and serving. Interestingly, while assessments like the countermovement jump are widely used to evaluate athletes' neuromuscular performance, upper-body testing protocols remain less commonly implemented in this sport. In response to this gap, a fairly new upper-body test known as the Athletic Shoulder (ASH) test has begun to be incorporated into evaluations within this cohort, aiming to measure isometric shoulder strength across three positions: I (180°), Y (135°), and T (90°). The purpose of this study was to examine positional differences in isometric strength during the ASH test among elite female volleyball players. Thirteen professional athletes competing at the SuperLeague level performed three maximal isometric contractions in each position using a force plate system. Significant differences were observed across positions ($p<0.001$). Force output in the I position was significantly higher than both Y ($p<0.001$, $g=1.793$) and T ($p<0.001$, $g=2.880$), with Y also exceeding the T ($p=0.015$, $g=1.439$). These findings emphasize the importance of incorporating the ASH test into regular athlete monitoring protocols in volleyball, as they help coaches identify potential weaknesses, develop individualized training programs, and better understand athletes' overall functional capacity.

Keywords:

Overhead Sports, Performance Monitoring, Force Plate, Upper-Body Strength.

INTRODUCTION

Volleyball is a team sport that involves high-intensity actions (jumping, changes of direction) interspersed with brief periods of rest [1, 2, 3, 4, 5]. Over recent years, with exponential technological growth, various assessments have been included in the training and monitoring process to evaluate athletes' progress, optimize their performance, as well as reduce the risk of injury [2, 6, 7]. These assessments often include technologies such as force plate systems, motion capture systems, and wearable inertial measurement units that allow practitioners to obtain objective data on neuromuscular performance, movement quality, and levels of fatigue [5, 7, 8, 9].

Correspondence:
Damjana V. Čabarkapa

e-mail:
dcabarkapa@sindgidunum.ac.rs

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Due to the nature of the sport, which involves frequent explosive lower-limb actions such as jumping, the countermovement jump (CMJ) is one of the most commonly utilized assessments in volleyball [2, 10, 11]. Data obtained from this assessment is then used by sports scientists and strength and conditioning coaches to analyze neuromuscular performance characteristics, track training adaptations, as well as guide further training decisions. However, relying solely on a single performance test may provide an incomplete or potentially misleading picture of an athlete's overall physical capabilities. Therefore, practitioners started incorporating additional tests such as isometric mid-thing pull (IMTP), drop jump, handgrip strength test, etc., in order to obtain a broader profile of an athlete's strength capabilities and overall performance [12, 13, 14]. However, despite the growing range of performance tests that are currently being implemented within the volleyball population, relatively few are specifically designed to assess upper-body strength and power characteristics. This can be considered an important limitation, considering that volleyball is an overhead sport where upper-body function plays a critical role in performance, as well as injury prevention [15].

The handgrip strength test, assessed via the dynamometer, has been widely used as a simple yet reliable indicator of athletes' upper body strength [14, 16]. In addition, previous research has indicated that this test has a significant correlation with performance outcomes in various sports, including serving velocity in volleyball [17] and throwing velocity in handball [14, 18], highlighting its importance in overhead sports. However, in 2018, a new upper-body assessment was introduced in the rugby setting [19]. Ashworth and colleagues developed an isometric upper-body strength test called the Athletic Shoulder (ASH) test, designed to evaluate shoulder strength in overhead positions that closely mimic sport-specific demands and that are most vulnerable to injury [19]. However, despite the growing popularity and use of the ASH test in overhead sports, there is still a significant lack of research exploring the use of this specific assessment in elite female athletes, particularly in volleyball. Additionally, limited data exist on how isometric strength differs between the I, Y, and T testing positions, each position targeting different components of the shoulder musculature. Therefore, the aim of the present study was to evaluate positional differences in force output during the ASH test among elite female volleyball players.

2. METHODS

2.1. PARTICIPANTS

Thirteen professional female volleyball players ($\bar{x}\pm SD$; age=22.1±3.5 years; height=184.5±6.7 cm; body mass=76.3±10.5 kg) competing at the SuperLeague level of competition participated in the present investigation. All procedures were approved by the Institutional Review Board (IRB) prior to data collection, and all participants were informed about the study's purpose and procedures, and written informed consent was obtained before participation.

2.2. PROCEDURES

Each athlete performed three maximal isometric contractions lasting 3 to 5 seconds with their dominant arm, with a 20-second rest between each attempt. The ASH test was conducted in a prone position, with the shoulder positioned at three consecutive angles of abduction (180°, 135°, and 90°). A one-minute rest was provided between each angle to minimize fatigue. The angles were pre-determined using a goniometer and properly marked to ensure consistency across trials (Figure 1).

To minimize extraneous movements, participants were instructed to maintain a neutral spine and avoid excessive trunk rotation or compensation. The dominant arm was identified based on self-reported handedness. A force plate system (Kinvent, Montpellier, France) (Figure 2) was used to assess maximal isometric force production, with data collected at 1000 Hz. The highest recorded maximal force value during the contraction was obtained for each position and used for the analysis.

Before testing, participants underwent a standardized warm-up, including submaximal contractions at each testing position, to ensure familiarity with the protocol. A practice trial was performed at each angle before data collection to reduce the learning effects.

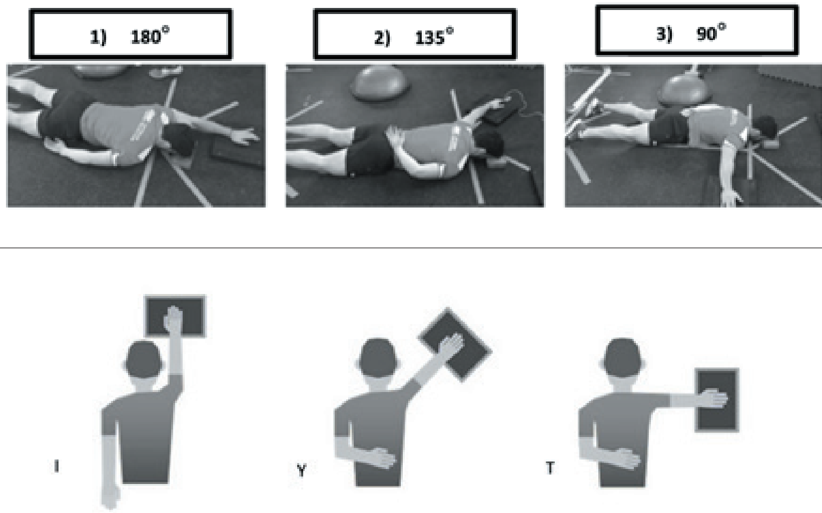

Figure 1. Graphical representation of each position during the Athletic Shoulder Test. [19]

Figure 2. Representation of the force platforms used in the present investigation

2.3. STATISTICAL ANALYSES

Descriptive statistics, means and standard deviations ($\bar{x}\pm SD$) were calculated for maximal force in each isometric position. Shapiro-Wilk's test corroborated that the assumption of normality was not violated for any of the dependent variables examined in the present study. A one-way analysis of variance (ANOVA) with Tukey post-hoc was used to determine statistically significant differences in maximal isometric force production between the *I, Y,* and *T* positions. Given the relatively small sample size (n=13), Hedge's g was used to calculate effect sizes (i.e., $g=0.2$ is a small effect, $g=0.5$ is a moderate effect, and $g>0.8$ is a large effect [20]). Statistical significance was set *a priori* to $p<0.05$. All statistical analyses were completed with SPSS (Version 26.0; IBM Corp., Armonk, NY, USA).

3. RESULTS

Significant differences in maximal force production during the ASH test were observed across the examined isometric positions ($F_{[2,23]}$=27, p<0.001) (Figure 3). Specifically, athletes generated the greatest force in the *I* position, which was significantly higher than both the *Y* (p<0.001, g=1.793) and *T* (p<0.001, g=2.880) positions. Force production in the Y position was also significantly greater than in the T position (p=0.015, g=1.439). On average, force production in the *I* position was approximately 24.81% greater than in the *Y* position and 46.90% greater than in the *T* position, while the *Y* position produced 17.70% more force than the *T* position.

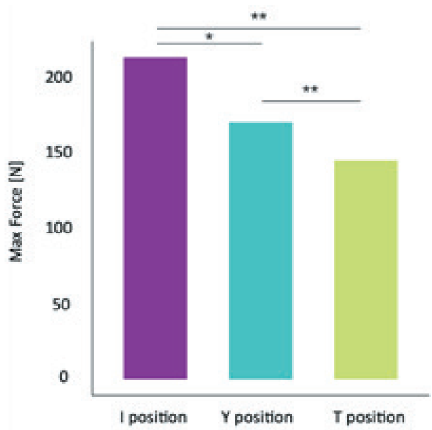

Figure 3. Graphical representation of maximal force production during the Athletic Shoulder Test in each isometric position. (*) – significantly different when compared to the Y position; (**) – significantly different when compared to the T position

4. DISCUSSION

The primary aim of this study was to examine positional differences in maximal isometric force production during the ASH test in elite female volleyball players. The results revealed significantly greater force output in the I position compared to both the Y and T positions, with the lowest force production observed in the T position. The aforementioned differences may be attributed to the muscle recruitment differences at different shoulder angles. For example, Joseph et al. [21] reported that the Y and T positions activate key periscapular and rotator cuff muscles, such as the lower trapezius and serratus anterior, to a higher degree, with lower trapezius activation exceeding 80% MVIC in both positions. While the Y position also demonstrated significantly greater serratus anterior activity, the T position showed reduced activation in the middle infraspinatus [21]. These findings, combined with the observed lower force outputs in the Y and T positions in the present study, suggest that these angles rely more heavily on smaller stabilizing muscles, in contrast to the I position, which likely allows greater contribution from larger prime movers and offers a mechanical advantage due to the arm being aligned with the line of force application.

Furthermore, similar observations to the ones in the present investigation have been noted by Ashworth and colleagues [19]. Specifically, during the ASH test, authors reported higher isometric force values in the I position among male rugby players (151.5±51.7 – 155.5±49.2 dominant arm; 144.9±48.9 – 143.4±47.3 non-dominant arm) when compared to the Y position (132.8±41.1 – 133.3±39.8 dominant arm; 125.2±37.5 – 132.7±38.7 non-dominant arm) and T position (123.8±32.8 – 125.4±35.6 dominant arm; 118.6±29.9 – 121.8±33.1 non-dominant arm) [19]. This is of critical importance for sports such as volleyball and rugby, as a great number of injuries in these sports occur during overhead actions such as attacking or throwing [19]. For example, in volleyball, the I position closely replicates the shoulder angle observed during the terminal phase of an attack or serve, where maximal shoulder flexion, external rotation, and force transmission are required. The ability to produce greater forces during this position may not only reflect an athlete's performance potential but also serve as a protective factor against common overhead-related injuries such as rotator cuff strains or labral tears [22, 23]. In addition, it is interesting to note that volleyball athletes seem to produce greater force during the ASH test, regardless of shoulder positioning, when compared to rugby athletes [19]. This may be attributed to the sport-specific demands since volleyball places greater emphasis on repeated, high-velocity overhead movements, and rugby involves more horizontal or forward-pressing movements (e.g., carrying the ball, tackling). Also, differences in training regimens that athletes went through, as well as the time point of the data collection during the season, can further explain these discrepancies. In addition, volleyball athletes were undergoing the ASH test frequently during their regular testing battery with their strength and conditioning coach thus, their familiarization with the assessment may have allowed them to obtain better results [24].

Lastly, while the findings of the present investigation provide valuable information regarding the isometric upper-body strength of elite female volleyball players, this study is not without limitations. The sample of athletes participating in the study was relatively limited in size and contained only female subjects. Hence, future research should examine if these findings are sex-specific as well as if they remain applicable to different levels of volleyball competition. In addition, it may be beneficial for practitioners to examine how the isometric upper-body strength differs across different positions in volleyball (e.g., outside hitter, middle blocker, libero).

5. CONCLUSION

In conclusion, the results of the present investigation highlight significant differences in isometric force production across the I, Y, and T positions of the ASH test in elite female volleyball players, with the I position eliciting the greatest force output. These findings emphasize the importance of incorporating the ASH test into regular athlete monitoring protocols in sports such as volleyball, as they help coaches to better identify potential weaknesses, develop individualized training programs, support injury prevention strategies, and obtain a better understanding of athletes' overall functional capacity. Also, this investigation is of critical importance as it contributes to the lack of elite female-athlete research and offers normative values for this specific group, which may help coaches and athletic trainers develop better training and recovery strategies.

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