

# ASH TEST AND SERVE VELOCITY IN ELITE VOLLEYBALL PLAYERS

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**Abstract:** The Athletic Shoulder (ASH) test is a novel assessment designed to measure the isometric force-time characteristics of the shoulder joint at three angles of abduction: 180° (I), 135° (Y), and 90° (T). Despite its increasing popularity, there is limited evidence linking this test to sport-specific tasks in overhead sports. This study aimed to provide normative data on peak isometric force during the ASH test and to examine its association with jump serve ball velocity in elite male volleyball players. We conducted a cross-sectional study involving 13 athletes. Peak isometric force in the I, Y, and T positions was measured using force plates, while jump serve ball velocity was assessed with a radar gun. The average peak force recorded during the ASH test was as follows: 199.15 ± 26.42 N in the I position, 193.38 ± 31.75 N in the Y position, and 173.69 ± 35.42 N in the T position. We found a weak positive, not statistically significant correlation between jump serve ball velocity and the peak isometric force produced in the I position ( $r=0.17$ ,  $p=0.574$ ) and weak negative, not significant correlations between jump serve ball velocity and the peak isometric force produced in the Y and T positions ( $r=-0.28$ ,  $p=0.357$  and  $r=-0.29$ ,  $p=0.344$ ). The univariate linear regression analysis showed no significant association between jump serve ball velocity and peak isometric force generated in any of the aforementioned positions: I ( $F=0.34$ ,  $p=0.574$ ), Y ( $F=0.91$ ,  $p=0.357$ ), or T ( $F=0.98$ ,  $p=0.344$ ). Our findings indicate that the peak isometric force produced in the ASH test is not a determinant of jump serve ball velocity in volleyball.

**Keywords:** ASH, Normative Data, Serve Speed, Elite Volleyball Players

## INTRODUCTION

Volleyball is an interesting, complex, and dynamic Olympic sport characterized by frequent high-intensity movements, where teams aim to score points through powerful attacks or by outsmarting their opponents (Gabbett et al., 2006; Lidor & Ziv, 2010). Since the basic elements of volleyball (e.g., serving and attacking) require a series of motor actions to be performed correctly and efficiently, it is crucial for coaches and physical trainers to understand the factors that affect the performance of these motor actions to achieve the best results. In volleyball, serving is a crucial skill that can significantly impact the game's outcome (Challoumas & Artemiou, 2018; Giatsis, 2022). Executing effective serves may lead to either a direct point (i.e., ace) or disruptions in the opponent's offensive play that may cause more errors and ultimately provide a strategic advantage to the serving team (Fernandez-Echeverria et al., 2015).

Ball velocity is a critical factor influencing serving effectiveness (Moras et al., 2008). The determinants of ball velocity can be categorized into three groups: the technique of the motion, anthropometric characteristics, and motor skills (Altundag et al., 2024). While training can enhance the technique of motion and motor skills, many morphological factors are primarily determined by genetics. Although high-performance players exhibit only minor changes in their throwing technique, their motor skills can still be significantly improved through regular training (Marques et al., 2008). Therefore, investigating the relationship between various motor skills and sport-specific tasks is crucial. The relationship between volleyball serve ball velocity and motor skills remains limited. Studies investigating the association between isokinetic strength tests of the upper limbs and volleyball serve ball velocity (Aka et al., 2019; Altundag et al., 2019), produced mixed results. Aka et al. (2019) found that serve and spike velocity in elite volleyball players had no significant correlation to the wrist and shoulder joint isokinetic strength. This finding is not consistent with the results of a study conducted by Altundag et al. in 2019, where the authors found a significant positive relationship between isokinetic shoulder muscle strength in the diagonal pattern and serving velocity among volleyball athletes ( $r=0.553-0.895$ ).

Despite previous investigations into the relationship between isometric strength and various sport-specific tasks in overhead sports such as tennis, baseball, and handball (Hayes et al., 2021; Arnold et al., 2022; Schwesig et al., 2016), a notable gap remains in the literature regarding its association with serve ball velocity in volleyball. One of the most commonly used upper-body isometric assessments in applied sport settings is the Athletic Shoulder (ASH) test, developed by Ashworth et al. in 2018. This test comprises a series of long-lever isometric upper-body actions performed on force platforms. During the assessment, the athlete lies prone while the tested shoulder is positioned at three consecutive abduction angles: 180° (I position), 135° (Y position), and 90° (T position). Because force is applied against a fixed device, the ASH test reduces measurement error related to the tester’s technique. Ashworth et al. emphasized that long-lever isometric tests more closely replicate the shoulder muscle demands of many sporting movements than short-lever tests, thereby enhancing the ecological validity of the assessment. However, despite its increasing use, the relationship between ASH test performance and serve ball velocity in volleyball has not yet been explored. To address this research gap, the aim of the study was to provide normative data on peak isometric force during the ASH test and to examine its association with jump serve ball velocity in elite male volleyball players.

## METHODS AND MATERIALS

### *Participants and Procedures*

This cross-sectional study was conducted in June 2025 in Strumica, North Macedonia, during national-team preparation for the CEV European Golden League. Participants were 13 elite senior male national-team volleyball players (22–31 y; ≥5 y competitive experience; ~25–30 h·wk<sup>-1</sup> volleyball-specific and strength & conditioning) who voluntarily participated in the study. All were medically cleared, free of musculoskeletal injury, and regular jump-serve users. To minimize learning effects before testing, athletes completed two familiarization sessions. To reduce interference from uncontrolled variables, all participants were instructed to maintain their habitual lifestyle. Testing followed a standardized team warm-up and a fixed order. First shoulder isometric strength was assessed with the ASH test (I/180°, Y/135°, T/90°) on a uni-axial force plate (ForceDecks Mini, VALD, Brisbane, Australia; 1,000 Hz, calibrated/zeroed between participants). 3 maximal trials of 30s were performed for each position with 60–90 s rest between trials and 2 min between positions. The highest peak force per position was retained. Jump-serve ball velocity was measured with a calibrated radar positioned 8 m behind the service line and 3 m above ground (contact-height alignment). After 10 warm-up serves, each athlete performed 5 valid jump serves with 60 s’ rest in between them. The highest velocity was analyzed.

### *Statistical analysis*

All statistical analyses were performed using a commercially available statistical software package. Descriptive statistics (mean, standard deviation, minimum, and maximum) were calculated for all variables. The Shapiro–Wilk test was used to assess the normality of continuous data. Differences in peak isometric force between the three ASH positions (I, Y, T) were examined using a Friedman repeated-measures ANOVA, followed by pairwise Wilcoxon signed-rank tests when the overall test was significant. The relationships between jump serve ball velocity and peak isometric force in each ASH position were evaluated using Pearson product–moment correlation coefficients with corresponding 95% confidence intervals. In addition, univariate linear regression analyses were conducted with jump serve ball velocity as the dependent variable and peak force in each of the three positions entered separately as the independent variable. The level of statistical significance was set a priori at  $p < 0.05$ .

## RESULTS

Participants had a mean age of  $27.23 \pm 6.6$  years, an average body weight of  $94.46 \pm 8.17$  kg, and an average height of  $195.15 \text{ cm} \pm 5.97$  cm. The demographic characteristics of the participants are presented in Table 1.

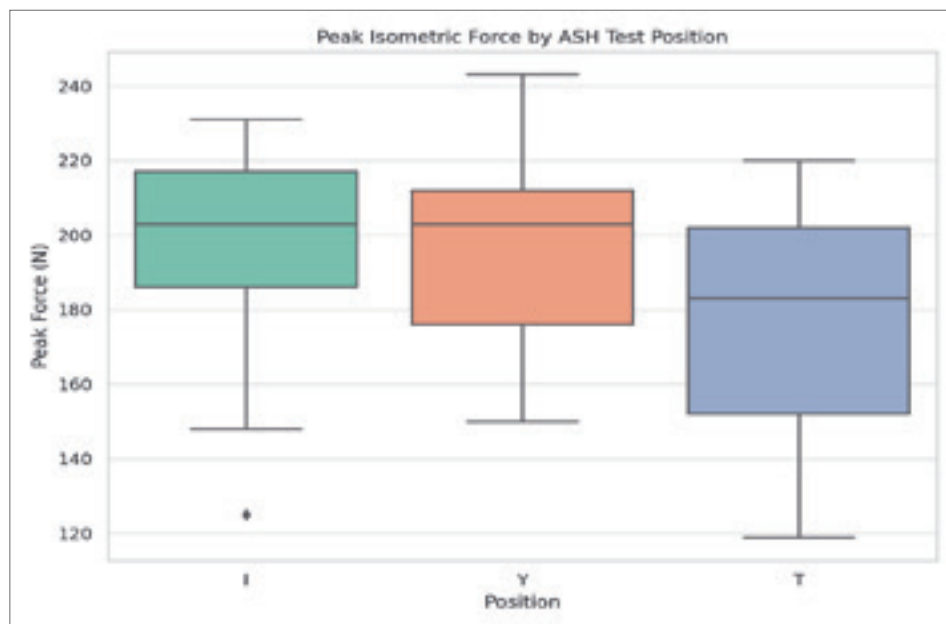
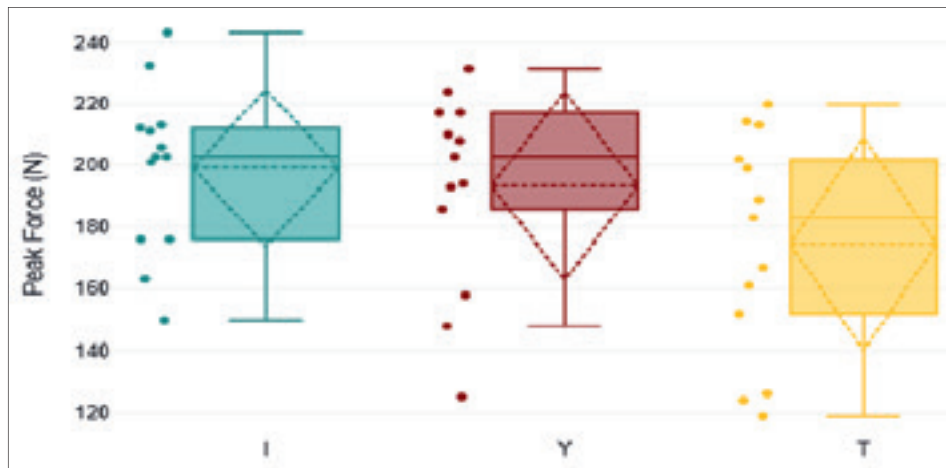
*Table 1. Demographic characteristics of the participants.*

Variables	n	Mean	SD
Age (years)	13	27.23	6.6
Body Mass (kg)	13	94.46	8.17
Body Height (cm)	13	195.15	5.97

During the ASH test, the highest peak force was recorded in the I position (180° abduction), with a mean peak force of 199.15±26.42 N. The minimum and maximum values observed were 150 N and 243 N. In the Y position (135° abduction), participants achieved a mean peak force of 193.38±31.75 N, with minimum and maximum values of 125 N and 232 N. The lowest peak force was generated in the T position (90° abduction), where the mean peak force was 173.69±35.42 N, with minimum and maximum values of 119 N and 220 N. The mean jump serve ball velocity among participants was 101.38±4.24 km/h, with minimum and maximum values of 95 km/h and 109 km/h. Peak isometric force in the I, Y, and T positions, and jump serve ball velocity, are presented in Table 2.

**Table 2.** Peak isometric force in I, Y, and T positions and jump serve ball velocity.

Variable	Mean	SD	Minimum	Maximum
ASH I (180°)	199.15	26.42	150	243
ASH Y (135°)	193.38	31.75	125	232
ASH T (90°)	173.69	35.42	119	220
Jump Serve Ball Velocity	101.38	4.24	95	109



**Figure 1.** Peak isometric force in I, Y, and T ASH positions.

A Friedman repeated-measures ANOVA revealed a statistically significant difference in peak force across the three shoulder positions:  $\chi^2(2) = 11.69, p = 0.0029$ . Post-hoc Wilcoxon signed-rank tests showed:

I vs Y: Not significant ( $p = 0.376$ )

I vs T: Significant ( $p = 0.002$ )

Y vs T: Significant ( $p = 0.006$ )

Figure 1 presents a bar chart comparison of the peak isometric force produced in the I, Y, and T positions of the ASH test.

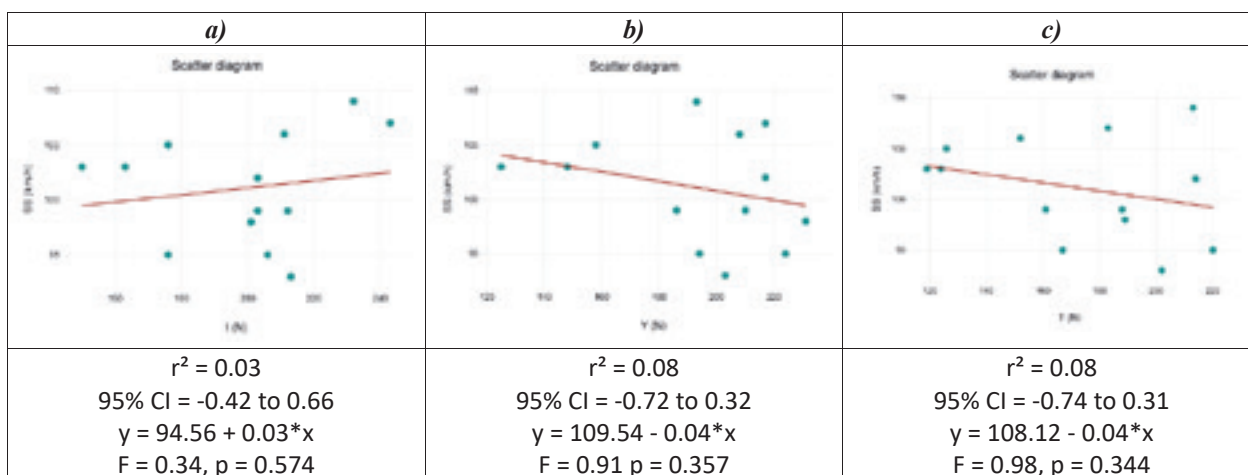
Pearson correlation analysis revealed a weak positive, not statistically significant correlation between jump serve ball velocity and the peak isometric force produced in the I position ( $r=0.17, p=0.574$ ) and weak negative, not significant correlations between jump serve ball velocity and the peak isometric force produced in the Y and T positions ( $r=-0.28, p=0.357$  and  $r=-0.29, p=0.344$ ). The results of the Pearson correlation analysis are summarized in Table 3.

**Table 3.** Results of Pearson correlation analysis.

Parameters	n	r (95% CI)	p
JSBV	I	0.17 (-0.42, 0.66)	.574
	Y	-0.28 (-0.72, 0.32)	.357
	T	-0.29 (-0.73, 0.31)	.344

Note: JSBV – jump serve ball velocity

The univariate linear regression analysis presented in Figure 1 showed no significant association between jump serve ball velocity and peak isometric force generated in either the I ( $F=0.34, p=0.574$ ), Y ( $F=0.91, p=0.357$ ), or T position ( $F=0.98, p=0.344$ ).



**Figure 2.** Results of univariate linear regression analysis. (a) Linear regression between jump serve ball velocity and peak isometric force produced in the I position. (b) Linear regression between jump serve ball velocity and peak isometric force produced in the Y position. (c) Linear regression between jump serve ball velocity and peak isometric force produced in the I position

## DISCUSSION

Based on the obtained results, the following can be observed: The average peak forces recorded during the ASH test were as follows:  $199.15 \pm 26.42$  N in the i position,  $193.38 \pm 31.75$  N in the Y position, and  $173.69 \pm 35.42$  N in the T position. Our participants demonstrated statistically significantly higher peak isometric force in the I and Y positions compared to the T position. To our knowledge, there is currently no existing evidence providing normative data on the peak force achieved in the ASH test specifically for volleyball players, nor on the comparison of force produced in the different shoulder abduction positions during the test. However, when compared to studies conducted in baseball and rugby, our results are consistent with their findings, which also show that participants exhibited higher isometric peak force values in the I and Y positions compared to the T position (Trunt et. al., 2022; Ashworth et al., 2018). The Pearson

correlation analysis revealed a weak positive correlation between the peak isometric force produced in the I position and jump serve ball velocity, as well as weak negative correlations between the peak isometric force generated in the Y and T positions and jump serve ball velocity. However, none of these correlations achieved statistical significance. Furthermore, the univariate linear regression analysis indicated no significant associations between the peak isometric force produced in the I, Y, or T positions and jump serve ball velocity. Overall, our findings suggest that peak isometric force generated in the ASH test is not a determinant of jump serve ball velocity in elite-level volleyball players. The relationship between peak isometric force in the shoulder joint and various tasks in overhead sports has been extensively studied. In contrast to our findings, a study by Baiget et al. (2016) found a strong positive correlation between serve velocity and isometric strength in shoulder internal rotation, as well as a moderate positive correlation between serve velocity and isometric shoulder flexion strength among competitive tennis players. The authors of that study reported that isometric strength in shoulder internal rotation and flexion accounted for 55% of the variance in tennis serve velocity. Aligning with our findings, Garcúa-Buendía et al. (2022) examined the link between shoulder internal rotation strength and standing throwing velocity in handball players and reported no significant covariation between the two variables. Additionally, in the context of volleyball, Terol-Sanchis et al. (2021) concluded that there was a strong correlation between isometric strength in shoulder internal rotation and the velocity of the power kick serve in beach volleyball ( $r = 0.76$ ;  $p < 0.05$ ), which contrasts with our results. The discrepancies between our study and that of Terol-Sanchis et al. (2021) may be attributed to differences in kinematic and kinetic factors between the jump serve in volleyball and the power kick serve in beach volleyball, as well as variations in the methods used to assess shoulder isometric strength. While both the jump serve and the power kick serve are dynamic movements requiring significant intra- and intermuscular coordination, beach volleyball athletes performing the power kick serve rely more on upper body strength to achieve higher ball velocities. This reliance is primarily due to the constraints of playing on sand, which limit their ability to generate kinetic energy from their lower body musculature. Furthermore, the methods used to quantify isometric shoulder strength show significant biomechanical differences. The ASH test, for example, involves longer levers and engages a higher percentage of upper body musculature compared to the shoulder internal rotation test.

The primary strength of this research lies in its status as the first study to investigate the relationship between the peak isometric force produced during the ASH test and jump serve ball velocity among elite volleyball athletes. However, several limitations should be considered. First, the findings should be interpreted with caution due to the small sample size, the specific characteristics of the population, and the method employed to assess shoulder strength, as well as the nature of the sporting task involved. Additionally, we relied solely on a non-time-constrained metric (peak force) to establish the association between ASH and jump serve ball speed. Finally, because this is a cross-sectional study, it does not establish causal relationships between the variables.

Despite the limitations of this study, we recommend that practitioners avoid using ASH test peak force values in isolation as indicators of jump serve performance in volleyball. Instead, the peak force produced in the ASH test may be more suitable for monitoring shoulder strength profiles, identifying asymmetries, or tracking rehabilitation progress (Trunt et al., 2022; Ashworth et al., 2018). Existing research (Ashworth et al., 2018) indicates that early indicators of rate of force development (RFD) and combined strength tests (such as ASH and jump tests) are more effective predictors of performance in dynamic overhead sports actions. Therefore, coaches are encouraged to incorporate combined, more sport-specific, ballistic assessments when evaluating or training for serving power.

## CONCLUSION

To our knowledge, this is the first study was to provide normative data on peak isometric force during the ASH test and to examine its association with jump serve velocity speed in elite male volleyball players. Our results indicated a weak positive correlation between the peak isometric force in the I position and jump serve ball speed and weak negative correlations for the peak isometric force in the Y and T positions relative to jump serve ball velocity. However, none of these correlations achieved statistical significance. The univariate linear regression analysis also demonstrated no significant association between peak isometric force in any of the I, Y, or T positions and jump serve ball velocity. Our findings indicate that the peak isometric force produced in the ASH test is not a determinant of jump serve ball speed in volleyball. However, due to the limitations of our study, further research in this area is necessary.

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Prilmljen: 30. oktobar 2025. / Received: October 30, 2025

Izmjene prilmljene: 08. novembar 2025. / Changes Received: November 08, 2025

Prihvaćen: 15. novembar 2025. / Accepted: November 15, 2025

