# RELATIONSHIP OF BODY COMPOSITION AND JUMP HEIGHT OF TOP VOLLEYBALL PLAYERS

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***Abstract:*** *The main goal of this research is to analyze the relationship between body composition and jump height of volleyball players. Jump height testing included vertical jumps: squat jump (SJ), countermovement jump (CMJ), and depth jumps (DJ25 and DJ45). To assess body composition, body mass index (BMI) was calculated, and a percentage of fat (%FAT), muscle mass (%MUS), and body water (%WAT) was measured. The sample of respondents consisted of 13 top male senior volleyball players of representative level (age: 25.4±3.3 years; weight: 93.0±4.2 kg; height: 199.1±6.7 cm). Canonical correlation analysis was applied to analyze the relationship between these two spaces. This analysis shows that only with the first canonical factor was a statistically significant connection between these two spaces observed (p= .039). In the area of body composition, the body mass index (BMI) has the highest projections on this factor (r: -0.80), while in the area of jumping, the countermovement jump (CMJ) has the highest correlation coefficient (r: -0.84). Other body composition parameters have very low projections on the first canonical factor, while in the area of jump height, depth jumps have relatively high projections (r: -0.78; r: -0.54). These results indicate that body mass index is an essential predictor for estimating the magnitude of vertical jumps, especially those with countermovement.*
***Key words:*** *body composition, jump height, relationship, top male volleyball players*

## INTRODUCTION

Vertical jump height is critical in many sports, as improving an athlete's vertical displacement can positively influence their performance (Häkkinen, 1993). Additionally, vertical jump height is often used to identify talent and predict future success in sports, particularly among adolescents during sensitive periods characterized by dynamic growth and development (Vaeyens et al., 2008; Nikolaidis et al., 2017).

Beyond physiological and biomechanical factors, body composition significantly influences vertical jump height (Abidin & Adam, 2013; Sharma et al., 2017). Numerous studies have reported that well-developed muscle mass and a low percentage of body fat are predictors of superior athletic performance (Ostojić & Živanić, 2001; Popović et al., 2013; Gligoroska et al., 2015). Body composition has been identified as a confounding factor in vertical jump performance, with several studies attempting to categorize the components of body composition that best explain athletes' jumping ability (Pérez-López et al., 2015). These studies further explore the nature of the relationship between body composition measures and vertical jump height (Davis et al., 2003; Marković & Jarić, 2007; Roschel et al., 2009; Aslan et al., 2011; Nikolaidis et al., 2013).

Two studies identified a significant negative relationship between body fat and vertical jump height in karate practitioners (Roschel et al., 2009), as well as in hockey players and cyclists (Sharma et al., 2017). Researchers also suggest that lower body fat values, representing excess weight during jumping, are advantageous. Similar results were observed in recreational athletes, where body fat percentage was negatively associated with vertical jump height (Davis et al., 2003). Marković and Jarić (2007) investigated the relationship between vertical jump height and body weight, concluding that vertical jump height is not dependent on body weight. Previous studies have not found a significant relationship between height and vertical jump height (Davis et al., 2003; Aslan et al., 2011; Aragón-Vargas & Gross, 1997).

Bioelectrical impedance analysis (BIA) is a reliable and valid method for assessing body composition parameters. This technique is noninvasive, safe, allows rapid measurements, requires minimal operator skill and participant cooperation, and is portable (Lukaski et al., 1985).

The most commonly used tests for assessing leg explosive power and jump height are the squat jump (SJ), countermovement jump (CMJ), and drop jump (DJ). Compared to other vertical jump tests, the SJ and CMJ tests are straightforward, practical, valid, and highly reliable measures of leg explosive power. The SJ is typically used to assess the concentric strength of the leg extensors, while the CMJ measures reactive leg power (Young, 1995).

This study aimed to examine the relationship between body composition and leg explosive power, as demonstrated through vertical jumps, in elite volleyball players and to investigate the predictive potential of body composition components for vertical jump height.

## METHODS

### Sample Description

The study sample consisted of 13 elite male volleyball players, members of the Slovenian senior national team (Age: 25.4 ± 3.3 years; height: 199.1 ± 6.7 cm; weight: 93.0 ± 4.2 kg).

### Measurement Instruments

Body height (BH) was measured using a Martin GPM 101 anthropometer (GPM GmbH, Switzerland) following standard procedures (Norton et al., 2000), with values recorded in centimeters (cm). Body mass (BM) and components of body composition, including body fat percentage (FAT%), muscle mass percentage (MUS%), and body water percentage (%Wat), were assessed using the Inbody 720 bioelectrical impedance analysis (BIA) scale. Body Mass Index (BMI) was calculated using the formula that relates body mass to the square of body height in meters.

Vertical jump performance was evaluated using the force plate (Kistler, Switzerland), which measured squat jumps (SJ) without arm swing, countermovement jumps (CMJ) with arm swing, and drop jumps from platforms at heights of 25 cm and 45 cm (DJ25 and DJ45).

### Statistical Analysis

The primary objective of this study was to determine the relationship between a set of variables assessing body composition and leg explosive power, expressed as jump performance. The canonical correlation analysis algorithm was employed using STATISTICA 12 for Windows (StatSoft, Inc., Tulsa, OK) to achieve this. The level of statistical significance was set at $p \leq 0.05$.

## RESULTS AND DISCUSSION

The Kolmogorov-Smirnov test indicated that the results were normally distributed, and Levene's test showed no violations of variance homogeneity. With the normal distribution of results in the domains of body composition and leg explosive power, parametric statistical procedures were possible (Table 1).

The results of anthropometric measures and body composition in our sample revealed that the mean age (25.4 ± 3.3 years), body height (199.1 ± 6.7 cm), body mass (93.0 ± 4.2 kg), and BMI (23.5 kg/$m^2$) were comparable to findings from previous studies. For instance, Palao et al. (2014) examined elite volleyball players participating in the Olympic Games and World Championships from 2000 to 2012, reporting values of Age = 27.4 ± 4.2 years, Body Height = 197 ± 0.07 cm, Body Mass = 88.7 ± 8.1 kg, and BMI = 22.9 ± 1.6 kg/$m^2$. Similarly, Giannopoulos et al. (2017) studied volleyball players in the Greek A1 division, reporting Age = 28.57 ± 4.87 years, Body Height = 196.89 ± 5.3 cm, Body Mass = 94.6 ± 9.06 kg, and BMI = 24.39 ± 1.9 kg/$m^2$. Marques et al. (2009) investigated elite professional volleyball players, reporting Age = 27.0 ± 2.9 years, Body Height = 193.2 ± 0.4 cm, and Body Mass = 92.3 ± 3.7 kg. Lastly, Sheppard et al. (2008) analyzed national-level volleyball players, reporting Age = 20.8 ± 3.9 years, Body Height = 201.3 ± 7.0 cm, and Body Mass = 93.0 ± 8.1 kg.

**Table 1** Descriptive Parameters of Body Composition and Leg Explosive Power

| Variable | Mean | Min. | Max. | Std.Dev. |
|---|---|---|---|---|
| Age | 25.4 | 20.5 | 30.1 | 3.3 |
| BH | 199.1 | 186.6 | 213.0 | 6.7 |
| BW | 93.0 | 83.3 | 99.0 | 4.2 |
| BMI | 23.5 | 21.8 | 24.5 | 0.9 |
| %FAT | 7.4 | 3.0 | 11.1 | 2.5 |
| %MUS | 53.1 | 46.5 | 56.5 | 2.4 |
| %WAT | 67.7 | 64.7 | 70.9 | 2.0 |
| SJ | 42.9 | 37.0 | 53.1 | 4.6 |
| CMJ | 47.9 | 41.1 | 54.6 | 3.8 |
| DJ25 | 34.5 | 27.1 | 41.3 | 4.5 |
| DJ45 | 34.3 | 27.6 | 42.5 | 5.0 |

Canonical correlation analysis was applied to determine the relationship between the two domains. Table 2 presents the results of the canonical correlation analysis between body composition and leg explosive power. These results indicate that only the first canonical function significantly explains the correlation between these domains (Canonical R = 0.96), accounting for 93% of the shared variance (Canonical $R^2$ = 0.93).

The remaining canonical functions contribute significantly less to explaining the shared variance, as their Canonical $R^2$ values are below 50% and lack statistical significance.

**Table 2** Canonical Relationships Between Body Composition and Leg Explosive Power

| Canonical function | Canonical R | Canonical R-sqr. | Chi-sqr. | df | p |
|---|---|---|---|---|---|
| 1 | 0.96 | 0.93 | 27.23 | 16 | **0.039*** |
| 2 | 0.67 | 0.44 | 7.76 | 9 | 0.559 |
| 3 | 0.60 | 0.36 | 3.36 | 4 | 0.500 |
| 4 | 0.04 | 0.00 | 0.01 | 1 | 0.915 |

Legend: Canonical R - coefficient of the canonical function; Canonical R-sqr. - coefficient of determination of the canonical function; Chi-sqr. - The chi-square test is used to test the significance of canonical functions, df - degrees of freedom, and p - statistical significance level of canonical functions.

The analysis of partial correlation coefficients, presented in Table 3, revealed a statistically significant direct correlation in the first pair of the canonical function (Can. 1) between BMI (-0.80) and CMJ (-0.84). This indicates a strong correlation, suggesting increased body mass index is associated with greater leg explosive power.

Other body composition components showed very low projections onto the first canonical function, making it uncertain whether they share variance with vertical jump performance.

Within the domain of leg explosive power, slightly lower correlation coefficients were observed for drop jumps with rebound DJ45 (-0.78) and DJ25 (-0.54) compared to CMJ. The correlation for SJ (-0.32) was notably low.

**Table 3** Structure of the First Canonical Factor for Body Composition and Leg Explosive Power

| **Body Composition** | | **Leg Explosive Power** | |
|---|---|---|---|
| Variable | Can. 1 | Variable | Can. 1 |
| BMI | **-0.80*** | CMJ | **-0.84*** |
| %FAT | -0.17 | DJ45 | **-0.78*** |
| %WAT | 0.16 | DJ25 | -0.54 |
| %MUS | 0.15 | SJ | -0.32 |

Legend: Can. 1 – canonical function; * – statistically significant correlation coefficient of the variable with the canonical function.

This study examined the relationship between body composition components and leg explosive power in elite volleyball players. Based on the presented results, it can be concluded that body mass index (BMI) shows significant correlations with vertical jumps driven by reactive leg power (CMJ, DJ45, and DJ25), while the correlations with squat jump (SJ), which reflects concentric strength of the leg extensors, are less significant.

This can be explained by the fact that BMI, as a ratio of body mass to the square of body height, is influenced by a higher proportion of muscle mass and greater body height in elite volleyball players. Similar findings were reported by Sheppard et al. (2008), where body height in volleyball players showed significant positive correlations with vertical jumps reliant on reactive leg power, such as CMJ ($r = 0.77$) and DJ35 ($r = 0.66$), while the sum of skinfold thickness, as a measure of body fat, had very low correlations with vertical jumps. These results can be interpreted through the paradigm of geometric scaling (Schmidt-Nielsen, 1992), which posits that strength is directly related to the cross-sectional area of muscles, which increases with body height. Our study supports this theory by the significant positive correlation between the body mass-to-height ratio and vertical jump performance driven by reactive leg power.

Our results also show a significant relationship between body height and vertical jump performance in the CMJ, DJ45, and DJ25 tests, aligning with findings by Maćkala et al. (2015), who reported a strong correlation between body height and torso length ($r = 0.93$). This supports the hypothesis that the propulsive phase of the applied tests—where reactive leg power and torso angular displacement are crucial—plays a decisive role in determining vertical jump height (Hsieh & Cheng, 2016).

## CONCLUSION

The results of this study demonstrate a clear and significant positive relationship between body composition components and vertical jump height in elite senior volleyball players at the national team level. Body mass index (BMI) strongly correlated with leg explosive power.

Except for %FAT, %WAT, and %MUS, BMI emerged as the primary predictor capable of explaining the variance in CMJ, DJ45, and DJ25 in this study. This is particularly emphasized by the prominent values of body height and the significant proportion of muscle mass in the players' body composition, substantially enhancing the reactive strength of the muscles involved in vertical jump execution.

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## POVEZANOST TELESNE KOMPOZICIJE I SKOČNOSTI VRHUNSKIH ODBOJKAŠA

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***Sažetak:*** *Osnovni cilj ovog istraživanja je analiza povezanosti telesne kompozicije i skočnosti odbojkaša. Testiranje skočnosti je obuhvatilo vertikalne skokove: iz mesta bez zamaha (SJ), iz mesta sa zamahom (CMJ), skokove posle saskoka sa platforme (DJ25 i DJ45), dok je za procenu telesne kompozicije proračunat indeks telesne mase (BMI) i izmeren procenat masti (%FAT), mišićne mase (%MUS) i vode u telu (%WAT). Uzorak ispitanika je činilo 13 vrhunskih odbojkaša seniora reprezentativnog nivoa (uzrast: 25,4±3,3 godine; težina: 93,0±4,2 kg; visina: 199,1±6,7 cm). Da bi se analizirala povezanost između ova dva prostora, primenjena je kanonička korelaciona analiza. Rezultati ove analize pokazuju da je samo kod prvog kanoničkog faktora uočena statistički značajna povezanost ova dva prostora (p= .039). U prostoru telesne kompozicije indeks telesne mase (BMI) ima najveće projekcije na ovaj faktor (r: -0.80), dok je u prostoru skočnosti skok sa zamahom (CMJ) sa najvišim koeficijentom korelacije (r: -0.84). Ostali parametri telesne kompozicije imaju vrlo niske projekcije na prvi kanonički faktor, dok u prostoru skočnosti skokovi posle saskoka sa platforme imaju relativno visoke projekcije (r: -0.78; r: -0.54). Ovi rezultati pokazuju da je indeks telesne mase važan prediktor za procenu veličine vertikalnih skokova, posebno onih sa zamahom pre skoka.*
**Ključne reči:** *telesna kompozicija, skočnost, povezanost, vrhunski odbojkaši*