

# RELATIONSHIP BETWEEN LOWER LIMBS LENGTH AND VERTICAL JUMP IN YOUNG VOLLEYBALL PLAYERS

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## Abstract

**Objectives:** To determine the relationships between anthropometric characteristics and vertical jump performance (VJP) in adolescent volleyball players.

**Method:** fifty two adolescent volleyball players (aged 14 to 17years) were studied. The following anthropometric measurements were determined: age, body weight, body height, and lower limbs length (LLL). Besides, two types of vertical jump (VJ) tests were performed: squat jump (SJ) and countermovement jump without arm swing (CMJ). Backwards stepwise analysis was determined in order to choose the potential predictors.

**Results:** Our results revealed a relationship between VJP and LLL. Our findings showed that prediction model was found to have an R square of 0.39 for SJ and of 0.42 for CMJ ( $P < 0.001$ ). **Conclusion:** This study provides evidence that LLL is strong predictor of VJP in young athletes and could be used by coaches and sports scientists as a mean of selection of young people especially in volleyball sports.

**KEYWORDS:** VJP. Anthropometric characteristics. Squat jump. Countermovement jump.

## 1. INTRODUCTION

The capacity to jump is a fundamental ability required in many sports [Scott, Briscoe, Craig, Markowski, Samuel, Saville, 2003]. Coaches and athletic trainers use the VJ test to determine an athlete's physical ability and to measure the outcome of a training program [Young, Wilson & Byrne, 1999; Cook, Malliaras, De Luca, Ptasznik, & Morris, 1999; Cook, Malliaras, De Luca, Ptasznik, & Morris, 2005]. The capacity of jumping was measured for the first time by Sargent in 1921 [Sargent, 1921]. VJ is considered one of the standardized protocol tests which is can used to evaluate the anaerobic power [Van Praagh, 2007].

Researchers have examined several factors that are thought to contribute to VJP (Aouadi, Jlid, Khalifa, Hermassi, Chelly, van den Tillaar, & Gabbet, 2012). These include jump technique, muscular force-velocity-power production, and anthropometric characteristics (Harman, Rosenstein, Frykman, Rosenstein, 1990; Al-Fadhli, Makki Ali, Fuad Saleeh, 2015).

Other investigations have examined the relationship between strength-velocity-power productions with VJP. Dowling and Vamos (1993) suggested that peak lower extremity power was an excellent predictor for VJ displacement. Yamauchi and Ishii (2007) studied the relationship between force, velocity and power output with the VJ displacement. The results demonstrate that maximum isometric force, maximum velocity, and maximum power output were positively correlated with VJ ( $r = 0.48, 0.68, \text{ and } 0.76$ , respectively;  $p < 0.001$ ).

Researches have also examined the relationship between some anthropometric measures and VJP [McLeod, Hunter & Etchison, 1983; Malina, Bouchard & Bar-Or, 2004]. McLeod et al., (1983) have examined the relationship between the percent body fat and VJP in high school. They demonstrated that VJP increased with the increase of body weight and the percent body fat until 10%. But they also showed that the excess of the fat mass doesn't have always a negative effect on VJP. In another research, Malina et al. (2004) have examined among young football players aged of 13 to 15 years the contribution of height and body weight on VJP. They concluded that only height contributes significantly to this ability.

Increasing VJ height is a critical component for performance enhancement in many sports particularly in the volleyball. Gabbett & Georgieff (2007) suggest giving an importance to the quality of jump in the practice of volleyball high-level. The knowledge of the factors that contributes to this ability is an important objective to optimize the performance of athletes in volleyball. It appears that few studies have examined the relation between anthropometric profile and VJ in volleyball players [Aouadi et al., 2012; Duncan, Woodfield, al-Nakeeb, 2006] especially in adolescent period, and many questions remain unanswered [Scott et al., 2003; Harman et al., 1990]. Therefore, the purpose of the current study was to examine the relationship between VJP and some anthropometric measurements, particularly the lower limbs length (LLL), in adolescent volleyball players, using a multiple regression analysis.

## 2. MATERIAL AND METHODS

**Subjects** Fifty two elite adolescent volleyball players participated in this study. The age of the participants varied between 15 and 16 years (mean age:  $15.45 \pm 0.51$  years; mean weight:  $70.4 \pm 11.0$  kg). Subjects were recruited among highly trained, competitive volleyball players. They trained 12–15 hours a week.

**Anthropometric measurements** In addition to age, the following measures were obtained: weight; height; sitting height and LLL. Trained anthropometrist measured height, weight, skinfolds, and sit using standard protocols in all subjects. All measurements were conducted on the same day; the same examiner measured all subjects for each specific test procedure. Weight was measured using an electronic digital scale (Seca, Hamburg, Germany). Standing and sitting heights were measured using a wall stadiometer and sitting height table (GPM – Swiss Made). Segmental limb lengths were measured using a Harpenden anthropometer (British Indicators Ltd); coefficient of variability was  $0.1 \pm 0.1\%$  [Norton, 1996]. Skinfold thickness was measured to the nearest 0.1 mm, at four sites (abdomen, thigh, triceps, and suprailiac) [American College of Sports Medicine, 1995], using a Harpenden calipers. The mean of three measurements represented the value for each site. All measurements were taken on the right side using anatomical sites according to the Jackson and Pollock [Jackson & Pollock, 1978; Jackson & Pollock, 1980]. Percentage body fat (%BF) was calculated using the Slaughter skinfold equation (Slaughter, Lohman, Boileau, Horswill, Stillman, Vanloan & Bembem, 1988).

**Physical performance testing :** All physical testing was conducted by the same investigator. Immediately After adequate warming up, VJ was determined for each subject using an Optojump system (Microgate SRL, Italy). After take-off, the loss of contact with the mat would activate the system, which would then record the flight time, converting it into the height in centimetres. The system was automatically activated as the test subject went through the space delimited by 2 photocells placed opposite each other and separated by a space of approximately 1.2 m. The passage of the subject through the first pair activated the system.

For each typical VJ (SJ and CMJ), three jump trials were performed by each subject; the best jump from three attempts was recorded and was used for analysis. There was a 15-second interval between attempts and a 3-minute interval between the different tests. The three typical VJ height tests are the following:

- Squat jump (SJ) with no arm swing. The subjects were instructed to keep their hands on their hips during SJ. Starting from the half-squat static position (knees at approximately  $90^\circ$ ), subjects were told to jump as high as possible in every one of the 3 attempts required.
- Countermovement jump (CMJ) with no arm swing: the subject in standing position executes a VJ after a fast bending of the knees to  $90^\circ$ . The subject must keep the hands to the hips during the whole movement.

**Statistical analysis: Data** were analyzed using SPSS software program, version 14.0. Analysis was conducted using the following descriptive statistic values for each variable: mean, standard deviations, minimum and maximum.

A step-wise multiple regression analysis was performed with VJ as the response variable. Several potential predictors were chosen to develop the equation: height, weight, %fat mass, and LLL. The backwards stepwise analysis was performed to determine a relationship between VJ and anthropometric characteristics.

### 3. RESULTS

Descriptive statistics including means and standard deviations, minimum and maximum for age; height; sitting height; weight; LLL; and %fat mass are shown in table 1. Moreover, in table 2 descriptive statistics including means, standard deviations, minimum and maximum for SJ and CMJ measurements are shown.

Regarding jumping, the results revealed an increment of jump height from SJ to CMJ. The augmentation in jump height from SJ to CMJ was determined as the mean SJ height subtracted from that of the CMJ ( $\Delta\text{jump-height}_{\text{CMJ-SJ}}$ ). Mean jump height was significantly ( $p < 0.01$ ) greater in CMJ compared with SJ, yielding an augmentation in jump height from SJ to CMJ ( $\Delta\text{jump-height}_{\text{CMJ-SJ}}$ ) of 1.8 cm (table 2).

**Table 1: Means, standard deviation, maximum and minimum of anthropometric data (n = 52).**

Measure	Mean $\pm$ SD	Minimum	Maximum
Age (years)	15.45 $\pm$ 0.51	15.00	16.00
Height (cm)	181.75 $\pm$ 6.36	166.50	192.70
Sitting height (m)	91.84 $\pm$ 4.36	84.50	107.00
Body weight (kg)	70.36 $\pm$ 11.01	51.50	97.00
lower limbs length (cm)	109.88 $\pm$ 5.6	95.50	121.00
% fat mass	16.3 $\pm$ 7.3	6.20	35.10

Values are mean (SD)  
LLL: lower limbs length

**Table 2: Means, standard deviation, maximum and minimum of VJP and comparison between SJ and CMJ (n = 52).**

Measure	Mean (SD)	Minimum	Maximum
SJ (cm)	31.68 $\pm$ 5.96	21.80	46.80
CMJ (cm)	33.47 $\pm$ 6.11 <sup>a</sup>	24.40	46.00

Values are mean  $\pm$  SD ; <sup>ab</sup> : significant difference between SJ and CMJ ( <sup>a</sup> :  $p < 0.01$ ; <sup>b</sup> :  $p < 0.001$  ) ;  $\pm$

SJ: Squat jump; CMJ: Countermovement jump; VJP: Vertical jump Performance.

The analysis of the results demonstrated the existence of a significant relationship ( $p < 0.001$ ) between anthropometric parameters and the two types of VJ. Indeed, the R square was of 0.51 for SJ, and 0.50 for CMJ. The main anthropometric characteristic contributing in the determination of the established model was the LLL with a positive relationship.

In determining the relationship between anthropometric characteristics and VJ, by backward stepwise analysis, the results of the multiple regression analysis (table 3) showed a significant ( $p < 0.001$ ) relationship between some LLL characteristics and the SJ and CMJ (figure 1a ; figure 1b). The R square was of 0.51 for SJ, 0.50 for CMJ (table 4).

**Table 3: Summary of multiple regression models for predicting vertical jump performance in volleyball players (n = 52).**

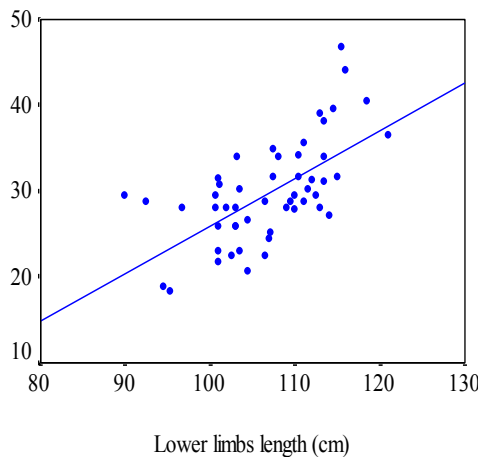
Dependant variable	Independent variable	Constant	B	Beta ( $\beta$ )	P
SJ	Lower limbs length	-13.00	0.32	0.30	0.04
CMJ	Lower limbs lengths	-6.28	0.16	0.31	0.04

SJ: Squat jump; CMJ: Countermovement jump. Beta ( $\beta$ ): Standardized coefficients.

**Table 4: The values of R multiple, R square and adjusted R for the multiple regression models of VJP (n = 52).**

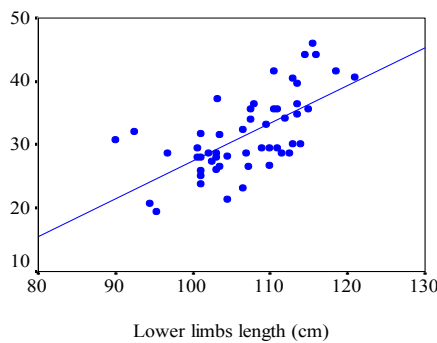
	R	R square ( $R^2$ )	adjusted $R^2$	P
SJ	0.72	0.51	0.47	0.0001
CMJ	0.71	0.50	0.46	0.0001

SJ: Squat jump; CMJ: Countermovement jump.



a

**Figure 1a:** significant relationship ( $R = 0.72$ ;  $p < 0.001$ ) between lower limbs length (LLL) and Squat Jump (SJ) performance in the volleyball players.



b

**Figure 1b:** significant relationship ( $R = 0.72$ ;  $p < 0.001$ ) between lower limbs length (LLL) and Countermovement Jump (CMJ) performance in the volleyball players.

#### 4. DISCUSSION

Our study showed that there was a significant difference in the jump heights between SJ and CMJ ( $p < 0.001$ ). In the literature, it is well established that subjects are able to jump higher in a CMJ than in a SJ. To explain why CMJ height is greater than SJ height, Bobbert, Gerritsen, Litjens, Van Soest (1996) showed in volleyball players that storage and reutilization of elastic energy could be ruled out as explanation for the enhancement of performance in CMJ over that in SJ. The greater jump height in CMJ was attributed to the fact that the countermovement allowed the subjects to attain greater joint moments at the start of push-off. As a consequence, joint moments were greater over the first part of the range of joint extension in CMJ, so that more work could be produced than in SJ (Bobbert et al., 1996). Our work offers, at least in part, a robust quantitative evidence to this conclusion.

Backward stepwise analysis has identified the measures of the body proportions that LLL contribute significantly to the VJP. Our data showed that anthropometric parameter could be significantly related to VJP (SJ and CMJ) for the adolescent volleyball players. The main anthropometric characteristic contributing in the determination of the established model was the LLL with a positive relationship. The contributions of these parameters are important and were of 50% for CMJ and 51% for SJ ( $p < 0.05$ ). These results are in accord with our anterior research realized in elite male volleyball players in which we demonstrated that the players with longer lower limbs have better VJP and higher anaerobic power. In fact, LLL is of major importance for the jumping performance in volleyball and that this has to be tested in training. This correlation explains that the VJP was higher in the players who have a greater lower limbs length. This effect could be due to the position of the center of mass of body which is related to the length of the lower limbs (Aouadi et al., 2012). The site of center of mass would be higher in the body when the lower members are longer [Le Gall, Beillot, Rochcongar, 2002] and therefore the jump height maybe more important.

It is interesting to note that height, sitting height, body weight, and %fat mass were not significantly correlated to the VJP. In the same way, Scott et al., (2003) showed that height and body weight were not significantly correlated to VJP. Investigating in this sense, Malina et al., (2004) studied the relationship between the anthropometric characteristics and VJP. They well demonstrated the contribution of the anthropometric characteristics on the VJP. But they didn't examine the part of the measurements of body proportions on this ability. In our research, we demonstrated that the measurements of the anthropometric proportions as the LLL have a significant effect in the contribution to the VJP.

Furthermore, our findings are comparable to those of Pelin et al. (2009) indicating that volleyball and basketball players were characterized by their longer LLL. Nevertheless, these results were in disagreement to those obtained by Scoot et al. (Sheppard, Dingley, Janssen, Spratford, Chapman, Newton, 2011) where they demonstrated that stature and body mass were not significantly correlated with VJP.

According to the data obtained by Rob et al (James, Carlos, Navas & Herrel, 2007), these results showed that differences in jumping high among individuals maybe related to morphological variables such as greater relative leg length, which would lead to greater available muscular power output and longer distance over which to accelerate during take-off, respectively. Our results are in opposition to those obtained by Davis et al. (Davis, Bosley, Gronell, Keeney, Rossetti & Mancinelli, 2006), examining the contribution of segmental skeletal length to VJP via the measurements of skeletal length of the trunk, femur, tibia and foot. Using regression analysis they observed that foot length was the only significant skeletal length predictor of VJP in men.

According to our previous study, the present study also showed that the lower extremity plays a main role in increasing VJP. Subjects with tall LLL tend to be superior jumpers than shorter subjects. This work is in accord with that of Sheppard et al. (Norton, 1996) who found that tall players have a distinctive advantage in that they can more rapidly defend space above the net due to their larger reach height in comparison to shorter athletes. The LLL was found to be highly correlated with CMJ with arm swing ( $CMJ_{arm}$ ) performance and anaerobic power in elite volleyball players (Aouadi et al., 2012). In the same previous study realized in elite volleyball players Aouadi et al., (2012), comparing the VJP in tallest and shorter players, they demonstrated that players with longer LLL had the better  $CMJ_{arm}$ . But, comparisons of  $CMJ_{arm}$  performances between tallest and shorter players revealed that tallest players had a greater but no significant VJ ( $p > 0.05$ ). The no significant difference could probably due to the fact that there were no differences in LLL between the two groups. Thus, tallest players do not have necessarily the longest lower limbs.

In conclusion, the relationship between LLL and VJP was well established in young volleyball players of 15 to 16 years. These results demonstrate the important role of the anthropometric characteristic in the contribution of VJP. The coaches could use the measurement of anthropometric characteristics, such as stature and LLL for talent identification in volleyball. Equally, these results appear to be relevant for volleyball player. Further research is required to validate these findings in other specific athletes requiring vertical jumping. The present study also suggests that the knowledge of the anthropometric profile could be a useful criterion in the selection and the orientation of the young for the practice of high level volleyball. But, it is important in the further researches to know the relationship between the anthropometric characteristics and the VJP in the different stages of adolescence period.

## 5. REFERENCES

1. Scott Davis D., David Briscoe, Craig A., Markowski, Samuel T., Saville E. and Christopher Taylor J. (2003). Physical characteristics that predict VJP in recreational male athletes. *Physical Therapy in Sport*, 4:167-174.
2. Young W., Wilson G., and Byrne C. (1999). Relationship between strength qualities and performance in standing and run-up vertical jumps. *Journal of Sports Medicine and Physical Fitness*, 39:285-293.

3. Cook J L, Malliaras P, De Luca J, Ptasznik R, Morris M. (2005). Vascularity and pain in the patellar tendon of adult jumping athletes: a 5 month longitudinal study. *British Journal of Sports Medicine*, 39:458–461.
4. Sargent DA. (1921). The physical test of a man. *American Physical Education Review*, 26:188–94.
5. Van Praagh E. (2007). Anaerobic fitness tests: what are we measuring? *Medicine and Sport Science*, 50:26-45.
6. Aouadi R., Jlid M.C., Khalifa R., Hermassi S., Chelly M.S., van den Tillaar R., Gabbet T. (2012). Association of anthropometric qualities with vertical jump performance in elite male volleyball players. *The Journal of sports medicine and physical fitness*, Feb;52(1):11-17.
7. Sareeh Abdulkarim Al-Fadhli S.A., Makki Ali A., Israa Fuad Saleeh. (2015). Influence of instantaneous torque exercises according to absolute angles for certain body parts in some of the variables biomechanics to tack off to vault and jumping events of athletics. *The Swedish Journal of Scientific Research ISSN: 2001-9211. Vol. 2. Issue 1. Jan. p. 11-15.*
8. Harman EA, Rosenstein MT, Frykman PN, Rosenstein RM. (1990). The effects of arms and countermovement on vertical jumping. *Medicine and Science in Sports and Exercise*; 22:825–833.
9. Selbie WS, and Caldwell GE. (1996). A simulation study of vertical jumping from different starting postures. *Journal of Biomechanics*; 29: 1137–1146.
10. Dowling JJ and Vamos L. (1993). Identification of kinetic and temporal factors related to vertical jump performance. *Journal of Applied Biomechanics*, 9:95–110.
11. Yamauchi J, Ishii N. (2007). Relations between force-velocity characteristics of the knee-hip extension movement and vertical jump performance. *Journal of Strength and Conditioning Research*. Aug; 21(3):703-709.
12. McLeod W.D, Hunter SC, and Etchison B. (1983). Performance measurement and percent body fat in the high school athlete. *American Journal of Sports Medicine*;11:390–397.
13. Malina RM, Bouchard C, Bar-Or O. (2004). Growth, maturation and physical activity. 2<sup>nd</sup> ed. Champaign (IL): *Human kinetics*.
14. Gabbett T, Georgieff B. (2007). Physiological and anthropometric characteristics of Australian junior national, state, and novice volleyball players. *Journal of Strength and Conditioning Research*. 2007 Aug; 21(3):902-908.
15. Duncan MJ, Woodfield L, al-Nakeeb Y. (2006). Anthropometric and physiological characteristics of junior elite volleyball players. *British Journal of Sports Medicine*; 40:649–51.
16. Norton K, Olds T. (1996). *Anthropometrica*. Sydney: University of New South Wales Press.
17. American College of Sports Medicine. (1995). Guidelines for exercise testing and prescription, 5th ed. Baltimore: Williams and Wilkins,
18. Jackson A, Pollock M. (1978). Generalized equations for predicting body density of men. *British Journal of Nutrition*; 40:497–504.
19. Jackson A, Pollock M. (1980). Generalized equations for predicting body density of women. *Medicine & Science in Sports & Exercise*. 12:175–182.
20. Slaughter MH, Lohman TG, Boileau RA, Horswill CA, Stillman RJ, Vanloan MD & Bemben DA. (1988). Skinfold Equations for Estimation of Body Fatness in Children and Youth. *Human Biology*;60, 5: 709-23.
21. Bobbert MF, Gerritsen KG, Litjens MC, Van Soest AJ. (1996). Why is countermovement jump height greater than squat jump height? *Medicine & Science in Sports & Exercise*. Nov;28(11):1402-1412.
22. Le Gall F., Beillot J., Rochcongar P. (2002). Évolution de la puissance maximale anaérobie au cours de la croissance chez le footballeur *Science & Sports*; 17 : 177-188.
23. Pelin C, Kırkçuoğlu A, Ozener B, Yazici AC. (2009). Anthropometric characteristics of young Turkish male athletes. *Coll Antropol.*; 33(4):1057-1063.
24. Sheppard JM, Dingley AA, Janssen I, Spratford W, Chapman DW, Newton RU. (2011). The effect of assisted jumping on vertical jump height in high-performance volleyball players. *J Sci Med Sport*. Jan;14(1):85-9.
25. James RS, Carlos A, Navas A, and Herrel A. (2007). How important are skeletal muscle mechanics in setting limits on jumping performance? *Journal of Experimental Biology*;210: 923-933.
26. Davis DS, Bosley EE, Gronell LC, Keeney SA, Rossetti AM, Mancinelli CA. (2006). The relationship of body segment length and vertical jump displacement in recreational athletes. *Journal of Strength and Conditioning Research*; 20(1):136-40.

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