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Vertical jump performances in recreational basketball players: the role of physical characteristics and anthropometric parameters of the lower limbs

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Abstract. The Vertical jump (VJ) test is a common functional measure of an athlete's current and potential level of athletic performance. There is paucity of investigations assessing the influence of lower limb anthropometric variables on VJ height in basketball players. The aim of this study was to determine the relationship between selected lower limb anthropometric parameters and VJ height among recreational basketball players in Lagos, Nigeria. *Material and Method*. Seventy seven male recreational basketball players, aged 16 to 35 years participated in this study. Body weight, height and BMI kg/m^2 were determined. Lower limb anthropometric parameters of femoral length, thigh girth, tibial length, calf girth, and foot length were assessed using a standard clinical tape measure while the subjects were in supine lying. The VJ test involving a countermovement jump was performed using a wall mounted centimeter tape. Data was analysed using Pearson product moment correlation to determine the relationship between VJ and anthropometric characteristics with significance set at $p < 0.05$. *Results*. No significant ($p > 0.05$) correlation of VJ height with femoral length, thigh girth, tibial length was seen. Calf girth and foot length had significant impact ($p<0.05$) while there were significant correlations of weight ($p < 0.001$, $r = -0.426$), height ($p < 0.001$, $r = -0.455$) and BMI ($p = 0.027$, $r = -0.252$) with VJ.
Conclusion: Physical characteristics of weight, height and BMI as well as anthropometric variables of calf girth and foot length had significant impact on VJ performance among recreational basketball players.
Key words: *Vertical jump, Anthropometry, Recreational sports, Basketball*

Introduction

Basketball is an aerobic-based anaerobic sport (1) which requires high intensity activities such as jumping (for rebounds, blocks and shots), turns, dribbles, sprints, screens and low intensity activities such as walking, stopping and jogging.

Anaerobic metabolism, force, velocity and peak power are determinant factors in many physical activities and sports (2). Explosive strength, take-off power, speed, and agility are abilities that contribute immensely to efficient movement and thus play an important role in basketball technique and tactics (3). The level of these abilities is most often measured using various motor tests with and without the ball (4) and it is perhaps best expressed by the vertical jump (VJ) (5). The vertical jump which is one of the most common actions performed by basketball players is a common action in most sports and is biomechanically similar to various acceleration and game-related dynamic movements (6).

The vertical jump test is a common field test used to evaluate anaerobic fitness improvements and the height achieved has a direct correlation with the amount of force produced by the muscle fibers (7). The vertical jump test is also a common functional measure of an athlete's current and potential level of athletic performance (8). Several factors could affect the performance during the vertical jump (9) and these include intrinsic factors such as gender, age, body composition, growth and maturity (10) while the extrinsic factors are predominantly related to lifestyle factors such as physical activity, environmental conditions, sport selection and training (2). However, a study by Aouichaoui et al (2) showed no significant correlation between some of these parameters and vertical jump parameters in Tunisian athletic children. Studies have also attempted to determine predictors of vertical jump height by variables such as muscular strength, flexibility, balance, body weight, and composition, and jumping technique which can be altered by training (11, 2).

Despite the efforts of many investigators, a strong prediction model for VJ height in basketball players has not been defined and this has led investigators to examine many different variables (12).
More fat causes more body weight that requires greater forces in order to overcome gravity force (13). Muscle size affects force producing and jump performance. There is a possibility that the greater the physiological cross section of muscles, the more sarcomeres they contain resulting in more cross bridges foundation and finally greater force production (14). The height that is achieved during the vertical jump has a direct correlation with the amount of force that is produced by the muscle fibers therefore; the greater force produced by the muscle fibers that are involved in the vertical jump is related to a greater maximum height achieved during jump performance (15).
McLeod et al (16) have examined the relationship between the percentage body fat and vertical jump performance (VJP) in high school students and demonstrated that VJ performances increased with increase in body weight and the percentage body fat until 10% body fat but they also showed that excess of fat mass does not always have a negative effect on VJ performance.
The influence of non-trainable variables of the lower limbs such as the length of an individual's body segments in predicting VJ height in basketball have not been established (8, 17) hence this study was designed to determine the relationship between selected anthropometric parameters of the lower limbs and vertical jump performances among recreational basketball players in Lagos, Nigeria.

Material and Method

A total number of 77 male recreational basketball players recruited from the Sports Centre of the University of Lagos and the National Stadium, Surulere Lagos participated in this study. Subjects recruited were recreational basketball players between 16 and 35 years of age who regularly played basketball at least an hour a day, three or more days per week for at least a year. They were not active participants in any other sport neither were they members of any professional basketball league. Excluded were players who had any history of recent surgery, recent fracture, musculo-tendinous injury or joint pathologies. Also excluded were basketball players with joint instability, neurological deficit, spinal pathology or any type of acute or chronic pain which restricts movements of upper limb, lower limb and trunk.
Ethical approval (ADM/DCST/HREC/APP/151) for this study was sought and obtained from the Health Research and Ethics Committee of Lagos University Teaching Hospital Idi-Araba, Lagos prior to the commencement of this study. Informed written consent detailing the purpose of the study was also obtained from each subject before the collection of data.
The study adopted a cross-sectional analytic survey design. A consecutive sampling technique was used to select participants for this study. The minimum sample size calculated was 32.
Prior to the evaluation of vertical jump (VJ), basic information was collected and it was ensured that the participants were in light clothing prior to the measurement of the anthropometric variables. All the anthropometric measurements were conducted on the same day for each of the participants by the same examiner who also conducted the evaluation for all the participants. The first station was set up to determine the body weight in kilogram using a weighing scale and at the second station, the subject's height in centimeter using a height meter was determined and the Body mass index (BMI) was calculated by dividing the weight in kilograms by the square of the height in meters (i.e., kg/m^2).
At the third station, the following anthropometric parameters of both lower limbs were assessed using a standard clinical tape measure to the nearest centimeter by palpation of the associated body landmarks while the participants assumed a supine position.
The femoral length was measured from the greater trochanter of the femur to the lateral joint line of the knee while the tibial length was measured as the distance from the medial joint line of the knee to the medial malleolus (17). The Foot length was measured as the distance from the posterior heel to the longest toe, the thigh girth from the largest visual point in the upper thigh and the Calf girth was measured from the largest visual point in the upper calf (17).
Prior to the VJ test, participants were led through a 3-minute warm up exercise (18) including jogging and stretching of the lower limbs. The VJ test was performed using a wall mounted centimeter tape and the participants were asked to stand straight with the dominant side next to the wall and both feet firmly on the ground (17).

The participants' finger tips were marked with chalk powder and were instructed to touch the wall as high as possible which was to measure the standing reach height. Participants then performed a countermovement consisting of bending the knees and hips while at the same time flexing the trunk following which they were instructed to lower themselves to a most comfortable point at the same time moving their arms back into hyperextension. The participants then leapt vertically as high as possible using both arms and legs to assist the body upwards and the highest point reached was marked and recorded (17). Three readings were taken and the best jump height was recorded. The difference in distance between the standing reach height and the jump height is the vertical jump height (17).

Data Analysis. The data obtained was analysed using Statistical Package for the Social Sciences (SPSS) version 20 for Windows and summarised using descriptive statistics of mean, standard deviations, frequency and percentage. Pearson product moment correlation was used to determine a relationship between VJ and anthropometric characteristics.

Results

The mean age of the participants was19.12 ± 4.52 years with more than half of them below twenty years of age. Table I shows the age, weight, height, and Body Mass Index (BMI) of the participants; the mean weight and height of the recreational basketball players being 76.77 ± 14.24 (kg) and 1.84 ± 0.08 (m) respectively. The mean BMI of the players which was 22.69 ± 3.70 kg/m^2 is within the normal range (18.5 – 24.5 kg/m^2). Table I also shows the relationship between the anthropometric parameters and vertical jump height. No significant correlations ($p > 0.05$) were evident for femoral length, thigh girth and calf length with vertical jump. There were significant correlations between the calf girth and foot length ($p<0.05$).

Table II shows that the mean vertical jump height was 0.50 ± 0.11 m. while the majority (33.75%) of the participants had a VJD of 0.51 - 0.60 m.

Table I. Relationship of Physical Characteristics and Anthropometric Variables with Vertical Jump

Variables	Mean ± SD	Range	r	p-value
Age (years)	19.12 ± 4.5	16 - 34	-0.022	0.985
Weight (Kg)	76.16 ±14.33	45 - 115	-0.426	0.001*
Height (m)	1.83 ± 0.08	1.66 – 1.99	-0.455	0.001*
BMI (Kg/m^2)	22.64 ± 3.64	15 - 34	-0.252	0.027*
Femoral Length	0.48 ± 0.04	0.39 – 0.61	-0.217	0.059
Thigh girth (m)	0.56 ± 0.05	0.47 – 0.69	-0.150	0.192
Tibial Length (m)	0.46 ± 0.03	0.39 – 0.55	-0.057	0.622
Calf girth (m)	0.37 ± 0.03	0.31 – 0.48	-0.287	0.011*
Foot Length (m)	0.29 ± 0.01	0.24 – 0.33	-0.248	0.030*

*Significant at $p<0.05$. Key: r = correlation; BMI = Body Mass Index

Table II. Vertical Jump Height of Participants

VJD (m)	Frequency (n)	Percentage (%)
0.21 - 0.30	3	3.75
0.31 – 0.40	15	19.48
0.41 – 0.50	20	25.97
0.51 – 0.60	26	33.76
0.61 – 0.70	10	12.50
0.71 – 0.80	2	2.50
0.81- 0.89	1	1.25
Total	77	100

Discussion and Conclusion

Basketball is becoming increasingly popular in many countries and is played worldwide by more than 450 million people. Identification of factors influencing vertical jump height may help in differentiating performance levels and provide data for basketball players of this category in Nigeria.

The purpose of this study was to investigate the relationship between selected anthropometric variables of the lower limbs and vertical jump performance among recreational basketball players.

Because of the lucrative nature of sports in both the amateur and professional categories, high performing athletes are highly sought and valued and one way of identifying and measuring potential performance has been by evaluating anthropometric and physiological characteristics. It is generally recognized that different anthropometric and performance characteristics are required to be successful in different sports, consequently, recent research has been focused on identifying the characteristics which are beneficial for participating in specific sports and over the last three decades there has been an increase in physiological and anthropometric measurements (19, 20).

Good vertical jump performance is considered critical to success in basketball (21) and the values of vertical joint height obtained in this study were consistent with other investigations involving recreational individuals (18, 22). In this investigation on male recreational basketball players, a mean VJ height of 0.50m was obtained (table II) while previous investigations on vertical jump height in basketball players have reported jumping height to range from 0.24 m (23) to 0.48 m. (24) Reeves et al (22) reported a mean VJ height of 0.51m for recreationally active men and women while Davis et al (8) reported an average VJ height of 0.59 m for male recreational athletes but made no attempt to identify the specific type of sport in which the participants participated and Ashley and Weiss (25) reported a mean VJ height of 0.27 m in college women. It can therefore be said that the mean VJ height reported in this study is similar to those of other recreational athletes and also athletes outside this region.

The non-uniformity of the population studied could be responsible for the contradictions seen in the findings of prior studies (table III), for instance, the investigation by Saiyed et al (17) was performed in a cohort of basketball, football, and cricket players. Also, in many of these studies, the level of skill/play was not too explicit but it was evident that no body length measurement produced a clear indicator for vertical jump performances among recreational athletes. It is evident from our study (table I) however, that femoral length, thigh girth and tibial length were not significantly correlated with vertical jump performance in recreational basketball players while calf girth and foot length were.

Table III. A Summary of Supporting and Contradictory Prior Studies

STUDY	Mean VJD	Femoral length	Thigh girth	Tibial Length	Calf girth	Foot length	Weight, height, BMI
Davies *et al* (2003)	Agree	-	-	-	Agree	-	-
Davies *et al* (2006)	Agree	Agree	Agree	Agree	Agree	Agree	-
Reeves *et al* (2008)	Agree	-	-	-	-	-	-
Lamonte (1990)	Agree	-	-	-	-	-	-
Saiyed *et al* (2015)	-	Disagree	Disagree	Disagree	Agree	Agree	-
Fattahi *et al* (2012)	-	Disagree	Disagree	Disagree	Agree	Agree	-
Aouchoui *et al* (2014)	-	-	-	-	-	-	Agree
Wyon *et a*l (2006)	-	-	-	-	-	-	Agree
Abidin *et al* (2013)	-	-	-	-	-	-	Agree

Key: '-'indicates variables which were not measured.

These findings agree partially with some results reported for lower limb anthropometry that no lower body segment measurement produced a clear indicator of vertical jump height (8) and also with the results of the study by Saiyed et al (17) which reported that femoral length, thigh girth, tibial length, calf girth and foot length have significant correlations with vertical jump performance in male sport players. The investigation by Saiyed et al (17) was performed in a cohort of basketball, football, and cricket players and this may account for the disparity in the results. A recent study by Mohemed et al (26) concluded that there was a weak correlation between the lower limb anthropometric parameters and the VJ which is in consonance with the findings from this study where the anthropometric measurements of the lower limb had weak negative relationships with vertical jump performance. Our findings show significant negative correlations between calf girth, foot length and vertical jump performance contrary to the results of Davis et al (18) who reported a positively significant correlation between calf girth and vertical jump performance in male recreational athletes. They theorized that the greater the right calf girth, the higher the vertical jump performance and increased calf girth is either related to cross sectional area of a muscle or the degree of body fat present in the calf area, though this report was not specific to recreational basketball players. In our study, the body composition of the players was not evaluated so there is a possibility that the calf girth could have been due

more to body fat rather that muscles which would have a negative impact on the VJ performance. Also, the players in our study were not evaluated according to their game position as did Fattahi et al (14) whose results showed that compared to the Spikers and Setters, the Liberos had negative significant correlations between the calf girth and VJ and indeed had the lowest VJ height. According to them, Liberos are the backline players who are more involved in receiving and digging during the match unlike setters and spikers who perform spike and block (27). Hence higher jumping is not an advantage for the Liberos. There is therefore the possibility that more Liberos could have been in the population of players in our study. Further investigations would be necessary on the relationship between the game position of the players, the anthropometric parameters and VJ performances.

Davies et al (8) investigated the relationship between trunk, femur, tibia and foot length with vertical jump performance in male and female recreational athletes and found that the length of the foot ($p = 0.033$) was the only significant skeletal length predictor of VJ height. It was hypothesized that for a given ground reaction force, the individual with the longer foot would generate more ankle torque due to the longer lever arm and additional propulsive force delivered in the vertical direction (8). One factor that may be responsible for the disparity seen is racial differences because the anthropometric features seen in Caucasians are different from that of Africans and there is presently a dearth of studies on vertical jump performance among athletes in this part of the world.

The results of this study indicate that a significant negative correlation exists between vertical jump performance and body weight, height and body mass index which also supports the findings of Aouichaoui et al (2) who reported that height and weight had an influence on vertical jump performances in a Tunisian athletic population though their study was carried out on prepubescent children as against the adult population in our study. Fat tissue has positive correlation with mass and body weight. More fat causes more body weight that requires greater forces in order to overcome the force of gravity (15). However, in contrast to the results of this investigation, Abidin et al (28) reported that height and body weight have no significant relationship with vertical jump among dancers and martial athletes respectively. However, the assessment based on weight and body mass index alone may not accurately predict body composition of an individual, because neither differentiates the proportion of body fat mass, lean body mass, and muscle mass of the total body mass (29). Further studies may be needed to investigate the association between body composition and VJ performances just as the results of a recent study suggested a strong positive correlation ($r = 0.8$) between variable fat free mass (%) and relative power in the investigations of VJ performances in professional basketball players (30).

The results of this investigation may give support to the hypothesis that skeletal length measurements of the lower limbs generally have no relationship with vertical jump performance among recreational basketball players as none of the parameters evaluated was significant except for a significant (p=0.03) weak negative correlation between foot length and VJ. Therefore, based on literature, strength and conditioning specialists should continue to focus more on improving anaerobic muscle power, while optimizing body composition to maximize VJ height especially as success in basketball requires good anthropometrical status, appropriate training and techniques in biomechanical and physiological aspects, strategies, disciplines and determination. Based on the results of this study, selected anthropometric variables of calf girth and foot length of the lower limbs as well as optimum physical characteristics like weight, height and BMI had significant impact on vertical jump performances among recreational basketball players.

Limitation of Study

The participants who participated in this investigation were mainly recreational basketball players and the body compositions as well as game positions were not evaluated. Future comparative studies with professional basketball players would be pertinent. In addition, the interaction of more variables such as muscular strength and power, flexibility, balance, coordination, body weight and composition, jumping technique and game position with vertical jump height should be investigated.

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