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RESEARCH PAPER

VARIATION IN ADIPOSITY INDICES, FITNESS INDEX AND Q-ANGLE WITH TYPES OF CONTACT SPORTS

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ABSTRACT

Common to every sport is the quest for high performance and desire to avoid injury. Low body adiposity has been connected to performance in sports, while increasing Q-angle is associated with increased lateral patella-femoral contact pressure and risk of knee injury. This non-experimental comparative study compared adiposity indices and Q-angle among football, volleyball and basketball players. A total of 68 male students comprising of 30 amateur footballers players, 19 amateur basketball players and 19 amateur volleyball players participated in the study. Selected and measured adiposity indices were body mass index, waist-hip ratio, percentage body fat, lean body mass and conicity index were measured among the participants. Results showed significant differences in body mass index (P=0.001), body fat (P<0.001), fat mass (P=0.002), fat free mass (P=0.04) and body adiposity index (P=0.001) among the participants groups, with volleyball players possessing significantly higher mean values for all adiposity indices. There was no significant difference in Q-angle among the three groups of players. It appears high body adiposity is common with volleyball players compared to basketball players. Volleyball players possess higher risk of obesity and poor physical fitness while risk of knee injury is not associated with any of sports at amateur level.

Key words: Adiposity, Fitness, Q-angle, Football, Volleyball, Basketball

INTRODUCTION

Football, volleyball and basketball are one of the most common played team games in the world, with football being unarguably the most popular sports in the world (Reilly and Gilbourne, 2003). Football also known as soccer refers to a number of sports that involve to varying degrees, kicking a ball with the foot to score a goal. It is played by a team of eleven players on each side and officiated by a referee and two linesmen (Reilly and Gilbourne, 2003). Volleyball as defined by International Olympic Committee is a team sport in which two teams of six players are separated by a net. Each team tries to score points by grounding a ball on the other team's court under organized rules. According to Federation of International Basketball Association, basketball is also a team sports, the objective being to shoot a ball through a basket horizontally positioned to score points while following a set of rules. Usually, two teams of five players each play on a marked rectangular court with a basket at each width end. Basketball is one of the world's most popular and widely viewed sports. Common to every sport is the quest for high performance and desire to avoid to injury, as the later definitely affects the former (McCaffrey *et al*., 2014).

In addition, low body adiposity has been connected to athletes' improved muscle strength and performance in sports (Zambudio *et al.*, 2014) and the anthropometric profile of players has been associated with measures of match-related performance (Arnason *et al*., 2004). For instance, Arnason et al reported a linear relationship between countermovement jump, leg power and percent body fat, and team success; that is, teams with higher fitness levels and lower percentage body fat had a higher league ranking. Invariably, as a rule of the thumb, low anthropometric indices suggest higher physical fitness and performance in sports, especially contact sports. Different sports have unique morphological requirement for effective competition and good performance in that sport, however, high physical fitness is an essential denominator among all competitive sports (Brocherie et al, 2014). Anthropometric index has been linked to performance indices such as counter-movement jump, leg power, Sprinting timing and team success, with players in higher league ranking having higher fitness levels and lower percent body fat (Arnason *et al.*, 2004; Brocherie *et al*., 2014). Contrary, high body adiposity is risk factor to sport injury and poor athletic performance. Recently, medically treated injuries have been shown to increase with increasing body mass index. (Janney & Jakicic, 2010). In fact, the odds of sustaining a medically treated injury were 15-48% greater among overweight or obese individuals compared to normal weight individuals (Janney and Jakicic, 2010).

Knee injury accounts for most injuries to the lower body during competitive sport, and include injuries such as patellar subluxation, patellofemoral joint dysfunction which are common in contact sports such as football, basketball and volley ball (Mizuno *et al*, 2001). These injuries have been linked to Q-angle (Jaiyesimi and Jegede, 2010). The Q-angle is an angle formed by quadriceps femoris. The quadriceps femoris is an important muscle that strongly contributes to the above movements. The twisting forces as well as other forces (brought about by running and kicking the ball, pitch and other legs) on the knee ligaments and muscles acting around the knee joint tend to compromise the normal configurations of the knee. This situation may lead to more knee symptoms and pathologies in later life (Thomee *et al*, 2000). The quadriceps femoris muscle angle (Q-angle) is the angle of incidence of the quadriceps muscle relative to the patella. It is a very important index of patellofemoral function and dysfunction (Jaiyesimi and Jegede, 2010). It is described as a reflection of the force of the quadriceps muscle on the patella in the frontal plane. Drawing an imaginary line from the anterior superior iliac spine (ASIS) to the centre of the patella and from the centre of the patella to the middle of the tibial tuberosity delineates the Q-angle (Jaiyesimi and Jegede, 2010).

Theoretically, a higher Q-angle increases the lateral pull of the quadriceps femoris muscle on the patella and potentiates patella-femoral disorders (Schulthies *et al*, 2010). The Q-angle is intended to provide some indication of the net lateral force applied to the patella-femoral joint by contraction of the quadriceps muscle. Both an invitro experimental study and a rhetorical modelling study have shown that increasing the Q-angle tends to increase the lateral patella-femoral contact while decreasing the Q-angle tends increase the medial patella-femoral contact pressure (Daneshmandi and Saki, 2010). Therefore, the Q-angle is an indicator of the imbalance between components of the quadriceps muscle (Kuhn, 2002). It has been shown to favour onset of pain and knee instability during sporting events (Raphael *et al*, 2010). As a way of assessing the comparative risk for injury and performance among amateur participants of contact sports, this study sought to compare adiposity indices, fitness index and Q-angle among football, basketball and volleyball players.

MATERIAL AND METHODS

Study Area: The study was carried out at the University of Nigeria Enugu campus (UNEC). University of Nigeria Enugu campus is situated in Ogui New Layout in Enugu North Local Government Area of Enugu State, Nigeria. UNEC has a land mass of approximately 120 acres. The campus comprises of six Faculties and fifteen Departments. The estimated number of students in the University is in the range of 5,500- 5,600 students.

Subject Description: The population for this study comprised all male undergraduates of University of Nigeria Enugu campus who engages in active amateur football, volleyball and basketball, and engaged in the game of choice at least twice a week.

Research Design: A non-experimental comparative design was employed in this study

Sampling Technique: The study utilized a purposive sampling technique which is a type of non-probability sampling technique that allows the investigator to select the subjects he deems typical of the population to be studied.

Inclusion Criteria: Students who are undergraduates in University of Nigeria, Enugu Campus. Amateur football, volleyball or basketball players who plays at least two times a week. Students who are within the age of 18-30 years.

Exclusion Criteria: Professional football, basketball and volleyball players, the physically challenged, participants with known heart and other related diseases, as well as students who engage in more than one of the games, were excluded.

Materials: Materials used for data collection were:

1. Stadiometer (Secca, England): A stadiometer calibrated in centimetre was used to measure the height of the participants. The participants were directed to stand barefoot on the platform with feet together and the eyes looking forward. The height was taken as the distance from the platform of the stadiometer to the vertex of the head and thus read off and recorded in the nearest 1.0 centimetre.

2. Electronic weight scale (HD-351 Tanita, USA): The weight of each participant was measured using an electronic weight scale, while the participant was putting on light clothing to avoid errors.

3. Measuring Tape (butterfly brand, china): An elastic tape rule was used to measure the hip and waist circumference. The participants were measured in standing position. Waist circumference was determined by placing the tape immediately below the lowest rib, at the narrowest waist (ASM site). The hip circumference was determined by placing the tape at the widest part of the hip. This usually corresponds to groin level in female and 2 – 3 cm inches below the navel in male.

4. Goniometer (E-Z Read, china): A long arm Goniometer was used to measure the quadriceps angle (Q-angle) of participants. Goniometer is an instrument that either measures an angle or allows an object to be rotated to a precise angular position. The participants were measured in standing position.

5. Gym Bench: This is usually of the height between 45 and 50cm. Gym bench was used in performing Harvard step test which is used in checking the fitness index of each participant. The participants were asked to step up and down on the bench following the metronome sound at a rate of 30 steps per minute for 5 minutes or until exhaustation. The heart rate (beats per min) is measured one minute after finishing the test as pulse 1, two minutes after finishing the test as pulse 2 and 3 minutes after finishing the test as pulse 3.

6. Stop Watch: This was used to measure the heart rate in beats per seconds.

7. Metronome: A metronome is a device that produces regular metrical ticks' in beats per minutes. This was used in Harvard step test to regulate the stepping up and down of the participant from the platform.

8. Bi-impedance fat analyser: This was used be used to determine the percentage body fat of the subjects. The subjects stood erect on the fat analyser and reading was read off. They did this while putting on light a clothing to avoid errors.

Ethical Consideration: Ethical certificate was obtained from the Ethical Committee of University of Nigeria Health Research Ethics Committee. An informed consent form was issued out to the participants during the research and participants had chance to withdraw from the study if they wished to. Every procedure was explained to the participants before engaging them in the study, and information about the participants was kept confidential.

Procedures for data collection: Sixty eighty male students comprising of 30 amateur footballers, 19 amateur basketball players and 19 amateur volleyball players participated in the study. The researcher issued an informed consent form to the participants which were read and signed. Prior to the study, a Physical Activity Readiness Questionnaire (PAR-Q) was also issued and filled by the participants to identify the students for whom physical activity might be inappropriate for.

In this study, selected adiposity indices include body mass index, waist ratio, percentage body fat, lean body mass and conicity index. Body mass index was estimated from measurement of height and weight, waist-hip ratio from waist and hip circumferences, lean body mass from body weight and percentage body fat while conicity index was estimated from waist circumference, body weight and height. Percentage body fat, body weight and were directly measured using bi-impedance fat analyzer. Waist and hip circumferences were measured using measuring Tape (butterfly brand, china).

Other adiposity indices used for this study was calculated from these basic ones. Height was measured using stadiometer to the nearest centimetre. Participants were asked to stand erect, and barefoot, with their backs touching the stadiometer, their arms held laterally by their sides and with the two feet closely apposed. Weight of each participant was measured using a weighing scale, with participant putting on light clothing to avoid errors. Percentage body fat was obtained using a bi-impedance electronic fat analyser. The Body Mass Index (BMI) was calculated from the weight (kg) and height (m) (weight/height^2) while the body adiposity index (BAI) was calculated from the hip circumference (cm) and height (m) using the formula (hip circumference / (height)$^{1.5}$) - 18. Waist and hip circumferences were measured using a tape measure and duplicate measurements were taken at each site and were obtained in a rotational order (ACSM, 2009). The waist-hip ratio was calculated by dividing the waist circumference (cm) by the hip (cm). The conicity index was calculated by dividing the waist circumference (m) by square root of weight (kg)/height (m) x 0.109. Body fat weight was calculated as follows: fat weight = %fat x weight / 100. Lean body mass was determined by subtracting body fat weight from total body weight. Fat mass index was calculated by dividing the fat mass by the square of height in metres while fat free mass index was determined using the equation for fat free mass/height (m) ^{2} (Bigaard *et al*, 2012).

Quadriceps angle (Q-Angle) was measured with a long arm goniometer while the participant is in standing position. The anterior superior iliac spine, the centre of the patella, and the tibial tubercle was palpated and marked. The fulcrum of the goniometer was positioned at the centre of the patellar. The immovable arm of the goniometer was placed in line with the anterior superior iliac spine while the movable arm of the goniometer was adjusted to be in line with a line drawn from the centre of the patella to the tibial tubercle (Weiss et al, 2013).

Fitness index was measured using the Harvard step test. It has been shown to be valid measure of fitness (Meyers, 1969). The participant warmed up for about 5-10 minutes and then step on the gym bench on the instruction of the researcher. The metronome and the stop watch were switched on while the participant steps up and down onto a standard gym bench of about 45cm high once every two seconds for five minutes (150 steps) or until exhaustion. Exhaustion is defined as when the subject cannot maintain the stepping rate for 15 seconds. The participant was instructed to follow the sound of the metronome while stepping up and down. The heart rate (beats per 30 seconds) was measured one minute after finishing the test as pulse 1, two minutes after finishing the test as pulse 2 and 3 minutes after finishing the test as pulse 3. Using the three pulse rates (beats per 30 seconds), an estimate of the fitness index was determined as follows: F.I=30000/ (2 x pulse 1 + pulse 2 + pulse 3) (Sharma et al, 2014).

Data was summarized using mean and standard deviation. ANOVA and Turkey Post Hoc test were utilized in the analysis. All data was analysed using the SPSS 17.0 software package for windows. Alpha level was set at 0.05.

RESULTS

A total of 68 players comprising of 30 footballers, 19 basketball players and 19 volleyball players, with age range 22-30 years participated in this study. Results showed significant differences in body mass index (P=0.001), body fat (P<0.001), fat mass (P=0.002), fat free mass (P=0.04) and body adiposity index (P=0.001) among the participants groups, with volleyball players possessing significantly higher mean values for all concerned indices of adiposity among the groups. Post-hoc test reveals that volleyball players differed from basketball players in body mass index (P=0.001), adiposity index (P=0.001), percentage body mass (P<0.001), fat mass (P=0.001), free fat mass (P=0.034), but did not differ from footballers in all of these indices (P>0.05). There was no significant difference in Q-angle among volleyball players, footballers and basketball players (P>0.05). Significant difference in percentage body mass was found between basketball players and footballers (P<0.05), with footballers possessing high body mass index than basketball players. Regarding fitness index, result shows significant difference among the groups (P=0.001), with footballers possessing highest mean fitness index, followed by basketball players and then volleyball players (Table 1, Table 2, and Table 3).

Table 1 shows that 68 players comprising of 30 footballers, 19 basketball players and 19 volleyball players participated in this study. It was observed that volleyball players have a higher mean value for all the adiposity indices and Q-angle across the groups. Footballers have higher mean values in all the adiposity indices than the basketball players while basketball players have a higher mean Q-angle than the footballers. In fitness index, footballers have the highest mean value followed by basketball players and volleyball players respectively.

Table 2 shows that there was significant difference ($p<0.05$) in Body Mass Index, Body Adiposity index, Percentage body fat, Fat Mass index, Fat Free Mass index as well as the Fitness Index among amateur football, volleyball and basketball players. This necessitated the need for Post Hoc analysis.

Table 1: Descriptive statistics showing Adiposity Indices, Q-angle and Fitness Index of Amateur Football, Volleyball and Basketball Players

Variables	Footballers N=30 Mean ± SD	Basketball players N=19 Mean ± SD	Volleyball Players N=19 Mean ± SD
BMI (kg/m^2)	22.62±2.09	21.05±2.19	24.04±2.90
WC (cm)	77.87±4.35	76.74±5.88	81.79±10.17
HC (cm)	91.70±4.87	91.53±5.65	95.16±7.93
WHR	0.85±0.03	0.84±0.04	0.86±0.04
CI (m^2/kg)	64.87±1.75	64.84±2.75	65.68±4.43
BAI	21.09±2.09	18.61±2.86	21.68±3.00
% Body fat	20.94±4.55	16.78±4.56	23.57±5.65
FMI (kg/m^2)	4.82±1.39	3.78±1.46	5.72±2.05
FFMI (kg/m^2)	17.82±0.78	17.36±0.88	18.09±1.02
LBM (kg)	53.64±4.14	56.67±4.51	56.55±6.50
Q-angle (^{0})	11.90±1.93	12.21±2.18	12.47±3.19
FI	93.50±23.87	86.95±19.40	66.53±25.84

Keys: BMI=Body Mass index, WC=Waist Circumference, HC=Hip Circumference, WHR=Waist-Hip Ratio, CI=Conicity Index, BAI=Body Adiposity Index, FMI=Fat Mass Index, FFMI=Fat Free Mass Index, LBM=Lean Body Mass, Q-angle=Quadriceps Angle, FI=Fitness Index

Table 2: ANOVA summary table showing the F and P-value of Adiposity Indices, Q-angle and Fitness Index of Amateur Football, Volleyball and Basketball Players

Variables	F -value	P-value
BMI (kg/m^2)	7.57	0.001*
WC (cm)	2.95	0.059
HC (cm)	2.315	0.107
WHR	1.479	0.235
CI (m^2/kg)	0.528	0.593
BAI	7.829	0.001*
Body fat (%)	9.435	0.000*
FMI (kg/m^2)	6.913	0.002*
FFMI (kg/m^2)	3.376	0.040*
LBM (kg)	2.978	0.058
Q-angle (^{0})	0.340	0.713
FI	7.809	0.001*

Keys: *=significant at $p<0.05$; F=fishers value; BMI=body mass index; WC=waist circumference; HC=hip circumference; WHR=waist-hip ratio; CI=conicity index; BAI=body adiposity index; FMI=fat mass index; FFMI=fat free mass index; LBM=lean body mass; FI=fitness index

Turkey post hoc test reveals significant difference in body mass index, adiposity index and free fat mass index between basketball player and volleyball players (p<0.05 in each). As regards percentage body fat, fat free mass significant difference was found to exist between basketball players and each of football players and volleyball players (P<0.05 in each). Result shows significantly higher fitness index in each of basketball and football when compared to volleyball players.

Table 3: Turkey Post-Hoc Comparison of Body Mass Index, Adiposity index, percentage body fat, fat free mass, free fat mass index and fitness index among Amateur Football, Volleyball and Basketball Players

	Footballers	Basketball players	Volleyball players
Body Mass Index			
Footballers	---	0.69	0.110
Basketball players	---	---	0.001*
Adiposity Index			
Footballers	---	0.69	0.110
Basketball players	---		0.001*
% Body fat			
Footballers	---	0.013*	0.165
Basketball players	---		0.000*
Fat free mass			
Footballers	---	0.070	0.147
Basketball players		---	0.001*
Free fat mass index			
Footballers	---	0.183	0.548
Basketball players		---	0.034*
Fitness Index			
Footballers	---	0.612	0.001*
Basketball players		---	0.026*

DISCUSSION

The BMI values showed that the subjects were non -obese, non-overweight and almost thin according to the available classification (Chatterjee et al, 2006). The fact that volleyball players possessed higher body mass index and free fat mass than basketball players may suggest that the risk of obesity and poor physical fitness is higher in volleyball than basketball. This contradicts the findings that professional basketball players possess higher body mass index when compared with volleyball players (Bandyopadhyay, 2004; Musaiger *et al.*, 1994). Although higher body mass index and fat free mass have been found in athletes when compare with non-athletic individuals (Palao, 2008; Wittich et al, 2011). The discrepancy in body mass index between this study and the previous studies may be due to lack of randomization as against simple or systematic randomization done in previous study (Mala et al, 2015; Bandyopadhyay, 2004 and Musaiger et al, 1994). The result of this study therefore must be interpreted with caution bearing in mind the weakness of BMI to differentiate muscle and bony mass from fat mass.

Professional footballers are accustomed with rigorous anaerobic and aerobic strengthening exercise with aim of gaining sufficient muscles for the sake of stamina, balance and control (Taylor et al, 2010). Taylor et al, (2010) observed that 97 percent of the professional football players they investigated had BMIs over 25. Football players were encouraged to increase their mass because of the type of athleticism required to play the sport, but not without caution that not all of the weight gained is healthy. While it is common place knowledge that footballers have huge muscles and bony masses, and hence high body mass indices, the relatively low body mass index and free fat mass found in this study may suggest that amateur basketball players rarely engage in similar rigorous anaerobic and aerobic training as with professional footballers. The lower body mass index, but not the lower free fat mass, found in basketball players may validate the fact that this game is occupied by individuals who are usually very tall and relatively higher rate of body movement and contacts than those of volleyball.

However, the high mean body fat percentage of the volleyball players could be as a result of the nature of their game, and suggests that volleyball is not vigorous as body contacts sports such as basketball. For almost all sports, low relative body fat is desirable owing to the high negative relationship between performance and percentage body fat, hence, the low mean value recorded among basketball players could point to the direction that basketball involves more physical activity of running and changing directions more than the football game. This is consistent with results obtained in Mala et al, (2010), in which higher percentage body fat was reported in volleyball players when compared with basketball players. According to Mala et al, (2010), the percentage of body cell mass which is an indicator of physical fitness and nutrition state of athletes was lowest female basketball players with softball scoring highest. This is mainly attributable to the high subscapular fat store in basketball players (Wilmore et al, 1998).

This study shows that there was no significant difference in Q-angle among the three groups of players. This suggests there was no relationship between Q-angle and type of sports among amateur athletes. The finding however, contradicts that of Fatahi et al, (2017) in which knee injury was correlated with Q-angle. The discrepancy could be attributed chiefly to lack of randomization of sample in this study, the difference in validity and the reliability of the measuring instruments used in both studies researchers, and the participant professional status. It appears that the level of engagement of amateur athletes in sport activities may not be sufficient to impact knee biomechanics and consequent Q-angle variability. This might account for the 'no difference' in Q-angle found in this study.

The fact that volleyball players, despite having higher free fat mass, possess significantly lower fitness index than each of basketball players and football suggests that level of fitness in amateur athletes is may be connected to body mass index and other factors other than fat free mass. The relatively long duration of a football match compared to that of volleyball players may suggests football players possess higher cardiovascular and muscular endurance than volleyball counterpart. This may account for the increased level of fitness found in football players. It could also be as a result of the contact nature of football and basketball against the non-contact nature of the volleyball. It could thus be opined that factors, other than fat free mass, such as cardiovascular and muscular endurance account for variation in level of fitness found among amateur athletes *(Hillsdon et al, 2005).*

Recognized limitations to this study include lack of random assignment and/or lack of control non-athletic group and method of anthropometry utilized. In conclusion, amateur athletes appear non-obese, non-overweight and almost thin. We thus recommend replication of this study using a larger sample size and employing random assignment, and non-athletic control or international counter parts.

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AUTHORS' CONTRIBUTION

The conception and study design were done by Uduonu E.M and Ezeukwu, A.O. Data was collected by Ezeakunne U. and Uduonu E.M. Data analysis and interpretation was done by Nweke, M.C, Eleje C.U, and Nwaka I.I. Manuscript preparation was done by Uduonu E.M, Nweke M.C and Uchenwoke C.I. Manuscript was critically reviewed by Ezema C.I and Ezugwu U. A