Skinfold Parameter as Predictor of Body Density for Undergraduate Female Students in a Nigeria University Community

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ABSTRACT

Background: The purpose of this study was to determine if some selected skinfold parameters are visible in predicting body density (BD) of undergraduate female students of Obafemi Awolowo University, Ile Ife.

Methods: Seventy five non- athletic female students, age ranged from 18 to 30 years old from Obafemi Awolowo University (OAU) Ile Ife, Nigeria participated in the study. Underwater weight was measured using Hydrostatic Weighing (HSW) equipment and skinfold was measured with Lange skinfold callipers using standard protocol at chest, biceps, triceps, forearm, midaxillar, subscapular, abdomen, suprailliac, thigh and lateral calf. Body density (BD) was calculated with underwater weight and skinfold measurement using some established equations. Descriptive statistics and Pearson Moment Correlation coefficient was used to analyse the data collected.

Results: The result showed that BD by HSW had significant negative correlation with skinfold at chest ($r = -.505$, $p < .001$), biceps ($r = -.302$, $p < .05$), midaxillar, ($r = -.328$, $p < .05$), thigh ($r = -.353$, $p < .05$), abdomen ($r = -.290$, $p < .05$) and suprailliac ($r = -.371$, $p < .001$).

Conclusion: The study concluded that the equation derived from the study is appropriate to determine the BD of Nigerian women.

Key Words: Body density; Skinfold thickness; hydrostatic and underwater weighing;

INTRODUCTION

Africa has witnessed increasing urbanization and changing lifestyles in the past four decades which have raised the incidence of non-communicable chronic diseases, especially cardiovascular disease (CVD) [1]. According to the World Health Report[2], cardiovascular disease accounted for 9.2% of total deaths in the African region in 2001, and hypertension, stroke, cardiomyopathies and rheumatic heart disease were the most prevalent causes. Several authors have confirmed obesity to be a major risk factor for many obesity related conditions such as type 2 diabetes mellitus, hypertension, heart failure, coronary artery disease, sleep apnea, musculoskeletal problems, gallbladder disease, metabolic syndrome, dyslipidemia, polycystic ovarian syndrome and some forms of cancer [3-12]. Although, it used to be regarded as a disease of industrialized countries, obesity, commonly defined as a body mass index (BMI) = 30 kg/m^2 is assuming an epidemic dimension globally [12, 13,14]. In a survey conducted in the United State of America from 1999 to 2000 the prevalence of obesity was found to be 30.5% while in the United Kingdom, it was 23% among men and 24% among women[15,16]. In the West African countries of Ghana and Republic of Benin, obesity was found in 13.6% and 18% respectively among adults [17,18] while Abubakari et al, [19] reported a prevalence of 10% in the West African sub-region with the odd of being obese being 3.2 among urban women compared to men. Nigeria is witnessing both demographic and epidemiologic transitions and these could be some of the possible reasons why the prevalence of non-communicable diseases is increasing. There is also a general misconception in Nigeria that obesity is a sign of affluence [20]. Wahab et al[21] affirmed in their study that there is a high prevalence of obesity in the northern part of Nigeria and women were significantly more affected. The high prevalence of obesity reported in that study was also independently associated with female sex, hypercholesterolemia and hyperuricaemia [21]. In a cross-sectional study in south western Nigeria, it was found that 21.2% of the respondents were obese[20] while in another study[22] obesity was found in 21% and 28% of males and females respectively. There is therefore an urgent need for intervention in order to reduce this burden and to prevent other non-communicable obesity - related disorders.

In order to prevent the increase in body fat in Nigeria, the measurement of body composition which primarily includes the distribution of muscle and fat in the body plays an important role. With the growing body of knowledge supporting the value of regular physical activity for reducing body fat and improving health and fitness, the evaluation of body composition has become an important aspect of adult fitness and medical rehabilitation programmes. In adult fitness and rehabilitation programmes, the major goal is to control body weight and fat with regular exercise and nutrition. Therefore accurate means of measuring body composition are required in order to monitor appropriately changes in body weight and body fat [23].

Among several methods for studying human body composition, one of the accurate laboratory techniques involves weighing the individual while submerged underwater, this is known as hydrostatic weighing (HSW)[24]. Dividing the body mass or weight by the body volume thus provides an accurate estimate of the density of the body, [24,25,26]. Hydrostatic weighing is a cheap laboratory test; available to determine the total density of the body and its subsequent composition into fat and fat-free mass. From the perspective of public health screening for individuals at risk for metabolic disease, estimation of body fat distribution using the available methods to accurately determine body composition, especially hydrostatic weighing are generally impractical for field use. It is therefore desirable to have available simple methods that can accurately estimate body composition [27].

Various researchers have derived regression equations using anthropometrics variables as predictors of body density for women [28-32]. These equations were obtained using the hydrostatic technique [30]. However, the equation that estimates the various body compositions, fat-free weight, fat weight and relative fat are population-specific. Therefore the use of these equations can only produce accurate result if subjects are drawn from populations similar to the population from which the equations were originally derived. The primary aim of this study was to determine if skinfold parameters are viable predictors of body density for Nigerian women.

MATERIAL AND METHOD

Seventy five participants who were female undergraduate students of Obafemi Awolwo University Ile Ife Nigeria participated in the study. Inclusion criteria were students that were apparently healthy and were off the menstruation period of their cycle.

Research design: A cross sectional descriptive survey design was used.

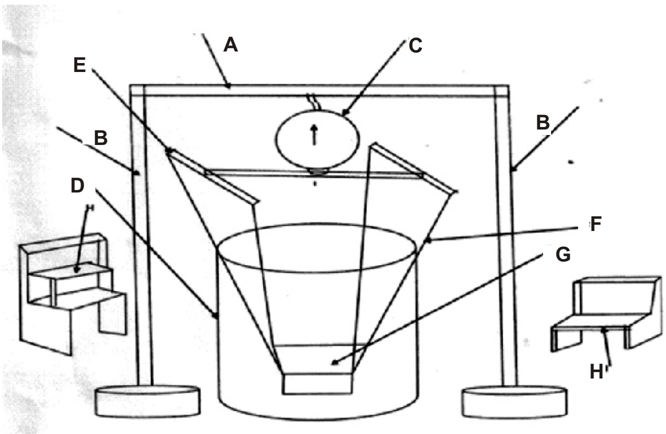
Sampling technique: The participants were non athlete female students who were randomly selected as they volunteered. Among 253 female students consulted 132 students volunteered but 75 students were qualified to participate in the study.

Incusion criteria: Each participant prior to HSW avoided vigorous activity, caffeine and other non-essential stimulants such as pop, candy and chocolate for 8 to 12 hours. They were fasted for at least 4 hours before the test, but they were well hydrated by drinking adequate amount of water. The subjects were also instructed to avoid foods that result in excessive production of gas and flatulence in the course of digestion such as beans, walnut, eggs, and pounded yam at least two days prior to test date.

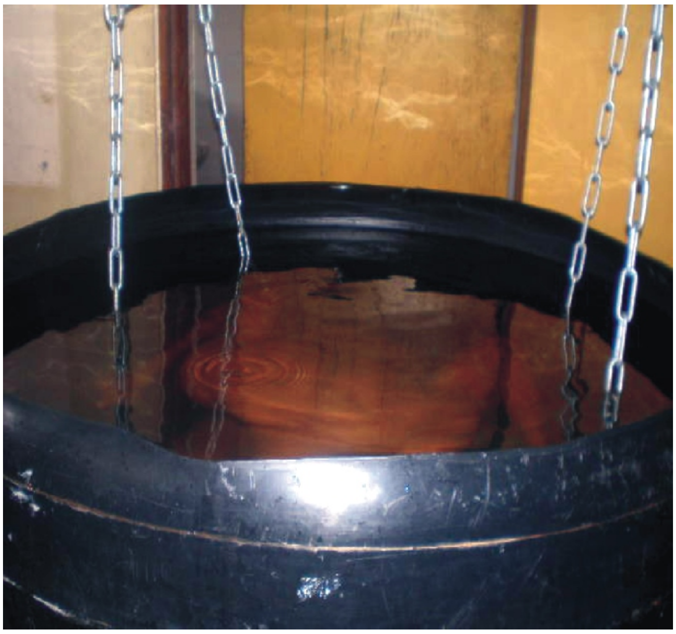
The restrictions were necessary in order to minimize the accumulation gastrointestinal gases which can affect the buoyancy of participants in water.

Procedure: The HSW apparatus used was a plastic water container (GEEPEE) with a volume of 2000 liter capacity. Apparatus was arranged such that the container (basin) was accessible. The tank was filled up with water with two uprights of metal of 2.1m height on each side of the container and joined at the top by a galvanized metal pipe of 1.83m. There were 2 stands, one outside the container and the other inside for the purpose of entry and exiting. A weighing scale (Hanson) with a capacity of 200 kg consisting of 2 hooks one at the upper end of the scale and the other at the bottom was used. The upper one was used to hang the scale on the horizontal bar which joined the two uprights while the lower one was used to hang the seat. The seat was hung to the weighing scale by 4 hooks with 4 metal chain one to each hook giving a distance of 0.60 meter from the foot rest to the floor of the container so that the subject can sit under the water with legs slightly bent and the water at neck level. (Fig 1)

Fig 1 Sketch of Hydrostatic Weighing Equipment



KEY: A = Galvanized metal pipe of 1.83m, B = Galvanized metal pipe with U-shape top and heavy base of 2.1m high. C = Weighing scale (Hanson) with a capacity of 200kg. D = Plastic water container (Geepee) with a volume of 2000 liter capacity. E = .02m diameter iron rod of .10m long. F = Metal chain of 1.12 meter long. G



PROCEDURE

The procedures of Salem et al were adopted in this study [28]. The weight of the chair in air and in water was measured before the subject entered into the water container.

The participants were asked to urinate and expel any gas or feces from the bowels prior to testing if there was such urge [24,27,]. Swim attire was worn which reduced the possibility of air traps. Long hair was cleansed of oil and tied back with a non metallic hair tie. Participants were asked to remove any jewelry on them. They were asked to comfortably seat in the weighing chair in water and were instructed to exhale as fully as possible while slowly leaning forward until the head was completely submerged underwater, (Fig 2). Participants were to remain motionless in the water for 5 to 7 seconds before coming up for air. While in water, the participants were instructed not to move deliberately in order to prevent water turbulence that could make the scale reading difficult. Five trials were done before the final reading was taken. The last 3 readings were recorded and the average calculated [24,26]. The water temperature was recorded with a thermometer. This was the weight in water.

The weight of subject outside the water was then measured .This was the combined weight of chair, chains and the subject. The underwater weight was then subtracted from the air weight; the result was the net underwater weight of the subject (WW).

The weight of participant was measured with bathroom weighing scale (Hanson Ireland), height was measured with calibrated height meter. Skinfold was measured using a Lange skinfold calipers (Cambridge Scientific International, Maryland, 3008239). The site for the skin fold measurement were : Chest, mid axilla, triceps, sub scapular, abdomen, supra iliac, mid thigh, mid calf, biceps and forearm [28]. Waist and hip circumference were measured using inextensible tape rule 150 cm long (Butterfly Brand, China). Body mass index= Weight / Height^2, Waist to Hip Ratio = waist circumference / Hip Circumference were calculated.

The Net Weight was calculated :
Net Weight (Nw) = Weight in Air (Wa) Weight in water (Ww)
Nw= Wa Ww and Body density (BD) by hydrostatic weighing was calculated as follows:

$$BD = \frac{Wa}{\frac{Wa \quad Ww \quad Rv + 100}{DW}}$$

Dw = Density of water, Rv = Residual lung volume (RLV): = 0.009 (age, years) + 0.032 (height, cm) 3.9 [29]

Table 1 Physical Characteristics of the Participants N = 75

RANGE	MIN	MAX	MEAN ± SD
AGE (Year)	18.00	30.00	22.92±3.02
HEIGHT (m)	1.49	1.79	1.64±.06
WEIGHT (Kg)	36.00	80.00	60.31±9.40
BMI (Kg/m^2)	14.61	30.48	22.30±3.37
WAISTCIR (cm)	59.00	91.00	74.74± 8.33
HIPCIR (cm)	66.00	12.00	93.23± 9.70
WHR	.68	.98	.80±.06
BDHSW	1.02	1.09	1.05± .01
PBFHSW	5.06	37.05	20.80± 6.45

Key: BMI = Body Mass Index. WAIST CIR. = Waist Circumference. HIP CIR = Hip Circumference WHR = Waist to hip ratio. BDHSW = Body Density by Hydrostatic weighing. Std. Dev. = Standard Deviation.

From table 2, the female body density by HSW had significant inverse correlation with chest skin fold (r = - .505, p < 0.01), bicep (r = -.302, p< 0.05), midaxilla, (r =-.328, p<.05), abdomen (r = -.290 p<.05), thigh (r= -.353, p< .05) and suprailliac (r =-.371, p< .001) The addition of some of the skin fold measurements also revealed significant negative correlation with BDHSW at p< 0.05. They are: Tricep +subscapularis+ suprailliac (TSSI), (r = -.300) and Triceps + thigh + Abdomen+ supra illiac (TTAS) (r = .356), also the addition of seven skin fold measurements, (chest + biceps + tricep + subscapular + mid axial + thigh + abdomen + suprailliac + calf + forearm) also showed significantly negative correlation with BDHSW (r =-.385, p < 0.01). Table 3 presents summary of regression analysis for the prediction of BD from skin fold measurements.

The predictor is BD, the constant value was 1.074 and the skin folds that predicted the BD were chest, biceps, triceps, subscapularis, midaxilla forearm and addition of triceps, thigh, abdomen and suprailliac. Presented in table 4 was the summary of correlation matrix on the relationship between BD from NDBD (Newly derived body density) equation, BD from 2 generalised equations of Jackson and Pollock [31], and BD from equations of 3 other authors. BD from NDBD had a negative and significant correlation at p < .001 with body density from equation of Jackson and Pollock [31] 1 at r = -.828, Jackson and Pollock [31] 2 at r = -.867, Behnke and

Table 2: Summary of correlation matrix of BDHSW and skin fold measurements for female (N = 75)

	BDHSW	CHEST	BICEP	TRICE	SUBSC	MIDA	THIGH	ABD	SUPILL	CALF	FORAR	TSSI	TTAS	CBTSMTA
Bdhsw	1													
Chest	-.505**	1												
Bicep	-.302*	.605**	1											
Tricep	-.263	.552**	.720**	1										
Subsc	-.235	.539**	.789**	.788**	1									
Midax	-.328*	.011	.058	.013	.063	1								
Thigh	.353*	.100	-.135	.222	-.101	.393**	1							
Abd	-.292*	.100	.048	.022	.640**	587**	.737**	1						
Supill	-.371*	.005	-.075	-.020	.582**	.546**	.793**	.803**	1					
Calf	.169	.040	.144	-.164**	.009**	.215	.641**	.316*	.273*	1				
Forar	-.241	.113	.093	.000	.026	.646**	.567**	.792**	.760**	.378**	1			
Tssi	-300*	.637**	.792**	.940**	.932*	.018	.-176	.047	.048	.103	.022**	1		
TTAS	-.376**	390**	.599**	.390**	.399**	.639**	478**	.555**	.540**	564**	952**	511*	1	
CBTSMTA	-321	-.580**	625**	.622**	598**	.690	.687**	.596**	.647**	593**	.511**	623**	511**	1

KEY: BDHSW = Body Density Hydrostatic weighing .Skinfolds measurements: Chest, Biceps, Triceps, Subscapularis, Mid Axillar Thigh, Abdomen (ABD), Supra iliac (Supill). TSSI Tricep +subscapularis+ suprailliac, TTAS =Triceps + thigh + Abdomen+ supra illiac. CBTSMTA = Chest + bicep+ tricep+ subscapular+ mid axillar + thigh + abdomen

Table 3 . Stepwise regression analysis showing prediction of BD from skin fold measurements for female. N = 75

Model	R	R2	Adjusted R2	SEE
1	.552a	.305	.209	.01310

Key. SEE = Standard error of the estimate
a. Predictor: (Constant), Chest, subscapularis
b. BD=1.074-0.001(Chest)-0.00004538 (subscapularis) + 0.001(Biceps) + 0.001(Triceps) + 0.001(forearm)

Table 4. Summary of Correlation matrix on relationship between body density obtained from derived equation and the generalised 2 equations of Jackson and Pollock 31 and 3 other

	NDBD	BDJP1	BDJP2	BDBW	BDPetal	BDSL
NDBD	1					
BDJP1	-.828**	1				
BDJP2	-.867**	.976**	1			
BDBW	-.887**	.958**	.945**	1		
BDPetal	-.847**	.969**	.963**	.918**	1	
BDSL	-.887**	.959**	.957**	.955**	.954**	1

**. Correlation is significant at the 0.01 level (2-tailed).
Key. NDBD = New derived body density equation=
1.074-0.001(Chest)-0.00004538 (subscapularis) + 0.001(Biceps) + 0.001(Triceps) + 0.001(forearm)
BDJP1 = Body density by Equation of Jackson and Pollock [31]

1= 1. 096095 0.0006952(tricep + suprailliac + abdominal + thigh) + 0.00000011(tricep + suprailliac + abdominal + thigh)^2 - .0000714(thigh).

BDJP2= Body Density by equation of Jackson and Pollock [31] 2 =1.097 -00046971(chest+midaxillary+triceps+subscapular+abdomen+suprailliac+thigh) +.00000056(chest+midaxillary+triceps+subscapular+abdomen+suprailliac+thigh)^2-001828(age).
BDBW = Body Density by Behnke and Wilmore [33]= 1.06234 0.00068 (Subscapular)-0.00039(triceps)-0.00025(age).

BDPetal = Body Density by Pollock et al [30]= 1.0902369-0.0009379(triceps + suprailliac + abdomen)+ 0.00000026(triceps + suprailliac + abdomen)^2 -0.0001087(age).

BDSL = Body Density by Sloan et al [32] = 1.0764 0.00081(suprailliac) -0.00088(triceps)

DISCUSSION

The evaluation of body composition provides valuable information on the health status of an individual and competitive preparation of athletes [34]. Methods such as HSW are not widely available and estimation techniques based on anthropometric measures have been adopted as a method of evaluating body density. The test -retest reliability of the equipment indicated a significant positive and high correlation with weight in air ($r = 0.95$ $p< 0.01$) ; weight in water ($r = 0.94$, $p<0.01$) and net weight, ($r = 0.96$ $p< 0.01$). This indicated that the constructed HSW equipment is reliable.
The mean BMI of participants in the study was 22.30 kg/m^2, showing that it was within the normal range of obesity according to WHO [14] where range of 18.5 kg/m^2 to 24.9 km/m^2 was considered normal. Other physical characteristics such as waist circumference, waist to hip ratio and percent body fat were also found to be within the normal values according to Klein et al [35], Bray and Gray [36] and ACE [37]. The reduction in the anthropometric values of the participants of this study might be due to the activities within the campus which might have raised the level of metabolism of the participants thereby reducing the fat content. The correlation of skinfold at triceps, mid axilla and thigh with BDHSW in this study was in agreement with the study of Jackson et al, [29]. In addition Jackson and Pollock [31] found that

skinfold at the chest, abdomen and suprailliac levels had negative correlation with BDHSW which is concurrent to the finding of this study. The addition of seven skin fold which had a negative correlation with BDHSW was also in agreement with the study of Jackson and Pollock [31]. Similarly, the combination of three skin folds of tricep, subscapularis and suprailliac which had negative significant correlation with BDHSW was supported by the work of Durnin and Womersley [38]; and the significant negative correlation which BDHSW had with sum of triceps, thigh, abdomen and supra illiac was in agreement with the research of Jackson et al, [29]. Based on the finding of this study the subcutaneous body adiposity of the participant of this study seems similar with the samples of the study of Jackson and Pollock [31], Jackson, et al [29] and Durning and Womersley [38].

Regarding the level of contribution of individual skinfold and addition of skinfold, to the prediction of body density by HSW. The highest beta coefficient of the sum of triceps, thigh, abdomen and suprailliac from the regression table is an indication that the addition of these skinfold had the highest contribution to the prediction of BDHSW. This was followed by triceps skinfold and chest skinfold. Most of the adipose tissues distribution of female concentrates more at the hip, thigh and suprailliac which is associated to gynoid obesity [39]. Body fat may be classified into upper body, android or male type and lower body gynoid or female type[36]. Individuals with a greater proportion of fat within the upper body especially within the abdomen compared with the hips and thigh have android obesity. Android obesity is generally seen with men whereas female generally carry greater proportion of their fat on hips and thighs [36]. This was reflected in this study.

The equation derived from this study was found to have a high, negative and significant correlation with 2 generalized equations of Jackson and Pollock [31] for prediction of female BD. There is also high significant correlation between BD from derived equation and BD from Sloan et al [32], Pollock et al [30] Behnke and Wilmore [34].

CONCLUSION

This study concluded that the participants of this study were not obese based on the measured anthropometric parameters and percentage of body fat using Hydrostatic weighing. There was a negative but significant relationship between BDHSW and skinfold at chest, biceps, mid axillar, thigh and abdomen. The equation derived that skin fold parameters are viable predictors of body density of Nigerian women.

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