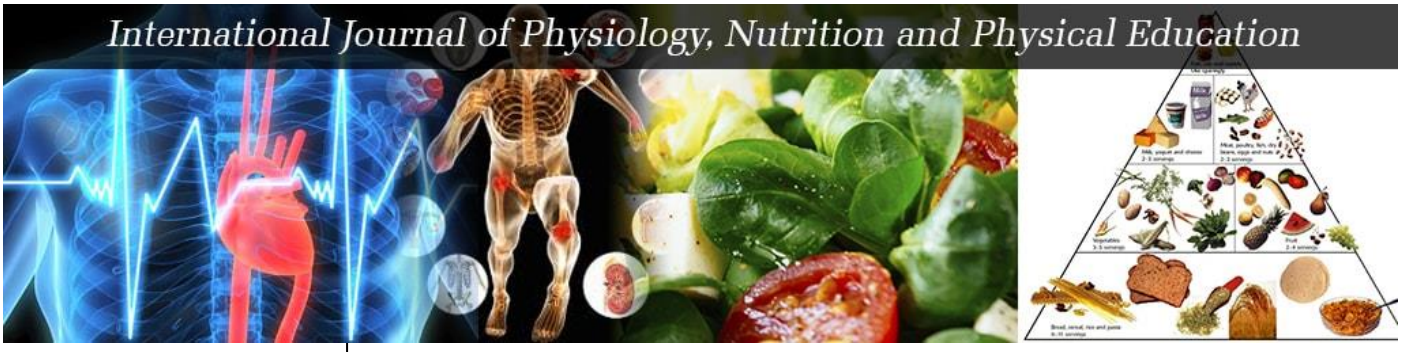

ISSN: 2456-0057
IJPNPE 2022; 7(2): 191-194

www.journalofsports.com
Received: 01-06-2022
Accepted: 05-07-2022

Shipra Malvi
Research Scholar, Department of Sport Psychology, Lakshmibai National Institute of Physical Education, Gwalior, Madhya Pradesh, India

Mahendra Kumar Singh
Prof. Lakshmibai National Institute of Physical Education, Gwalior, Madhya Pradesh, India

Anchal Sharma
Research Scholar, Department of Yogic Science, Lakshmibai National Institute of Physical Education, Gwalior, Madhya Pradesh, India

Ankit Singh
Research Scholar, Department of Physical Education Pedagogy, Lakshmibai National Institute of Physical Education, Gwalior, Madhya Pradesh, India

Corresponding Author:
Shipra Malvi
Research Scholar, Department of Sport Psychology, Lakshmibai National Institute of Physical Education, Gwalior, Madhya Pradesh, India

Revalidation of different circumference and skin fold methods of fat measurement in Indian condition

Shipra Malvi, Mahendra Kumar Singh, Anchal Sharma and Ankit Singh

DOI: https://doi.org/10.22271/journalofsport.2022.v7.i2d.2586

Abstract
The aim of this study was to revalidate the skin folds methods and circumference methods for estimating the fat in Indian conditions. Fifty women of 18–26 years of age randomly selected from hostels of Devi Ahilya Vishwavidyalaya, Indore. The circumference and the thickness of fold of skin was measured with the help of a plastic with fiber glass freeman's standard measuring tape and the ABS Plastic made skin fold caliper for the required sites. For establishing the validity of various circumference and skin fold methods for measuring the fat percentage Tanita body fat analyzer was used as criterion measure. For comparing the fat measurement calculated through various techniques of circumference and skin fold methods and the criterion bioelectrical impedance, one way analysis of variance statistics was applied. To establish the reliability, objectivity and validity of the instrument for estimating the fat percentage the level of significance was set at 0.05, which was considered adequate for the purpose of the study. All measurement technique *viz*. circumference / skin fold are having a positive significant correlation with criterion i.e. Bioelectrical Impedance analysis using Tanita body fat analyzer. Whereas, only US NAVY method 2 is very similar to criterion i.e. bioelectrical impedance analysis technique and the best circumference method for measuring body fat. The two formulas for us navy method abdominal circumference instead of waist circumference is more suitable for measuring body fat for young Indian women.

Keywords: Circumference methods, revalidation, and skin fold method

1. Introduction
According to O'Brien and Dixon (2002) [10], obesity is one of the most prevalent disorders and a major global health concern. Since 1980, the rate of obesity has nearly doubled globally, with 200 million men and 300 million women today suffering from the condition (World Health Organization, 2022) [11]. This also indicates a higher prevalence of obesity among women (Mehrotra *et al*., 2016) [9]. Obesity can gradually cause and/or exacerbate a wide range of co-morbidities, including type 2 diabetes mellitus (T2DM), hypertension, dyslipidemia, cardiovascular disease (CVD), liver dysfunction, respiratory and musculoskeletal disorders, subfertility, psychosocial issues, and certain types of cancer, depending on the rate and duration of weight gain (Kyrou *et al*., 2000) [8].

The current data disclosed by world health organization on prevalence and impact of obesity is more alarming in INDIA (World Health Organization, 2022) [11]. India is third top most country after U.S and China to give rise to this health calamity (World Health Organization, 2022) [11]. According to the world health organization, latest estimates, 6.8% (UI 6.1 to 7.6) of children and adolescents aged 5–19 years worldwide were obese in 2016, up from 2.9% (UI 2.6 to 3.2) in 2000 and 4.9% (UI 4.6 to 5.3) in 2010. The prevalence of obesity in that age group has increased in all WHO regions since 2000, but has remained the highest in the Region of the Americas where it reached 14.4% (UI 12.4 to 16.6) in 2016. 2 Among adults aged 18 years and older, the age-standardized prevalence of obesity also increased between 2000 and 2016 across all WHO regions. Prevalence was estimated at 13.1% (UI 12.4 to 13.9) globally in 2016 and ranged from 4.7% (UI 3.9 to 5.6) in the South-East Asia Region to 28.6% (UI 26.6 to 30.5) in the Region of the Americas. Among women aged 15–49 years, the

prevalence of obesity across 54 low- and middle-income countries was also lowest among those in the poorest quintile (median 2.5%) and increased stepwise by income quintile to a median 15.4% in the richest quintile. Prevalence was roughly similar across women with no, primary and secondary education (medians of 7.5% to 10.3%), but was markedly higher among women with higher education.

The parameters and guidelines to detect obesity and overweight have been very distinctly given by world health organization (World Health Organization, 2022) [11] The major cause for this is attributed to lower socioeconomic status, lack of education as well as lack of knowledge to use obesity and overweight detective methods and devices. Therefore is it essential to understand the difference between obesity and overweight. The values of body weight adjusted for height, referred to as body mass index (BMI: in kg/m^2), in excess of 25 and 30 are considered to indicate overweight and obesity respectively. Though the term is often interchangeably used, they have different meanings and guidelines given by WHO. The terms "overweight" and "obesity" refer to body weight that is greater than what is considered normal or healthy for a certain height. Overweight is generally due to extra body fat. An ideal fat percentage for good health is between 10% to 15% for young men and between 20% and 25% in women. Body fat percentage greater than 20% for men and 30% for women are considered an indication of obesity (Definition & Facts for Adult Overweight & Obesity). There are many standard procedures to detect obesity, though BMI is the most commonly used method (Mehrotra *et al*., 2016) [9].

there are many other procedures like bioelectric impedance analysis (BIA), circumference methods, waist to hip ratio, Near -infrared measurement, Skin fold thickness, under water weighing, dual energy x-ray absorptiometry, Air displacement Plethysmography, Computed tomography (Hills, 1998). Circumference and Skin fold thickness method has been commonly used as a method to estimate body fat in clinical practice (Duren *et al*., 2008) [3]. An indirect way of estimating body fat is the thickness of the skin folds at one or more places (Barrow & McGee, 1979) [1]. It is generally recommended that the sum of measurement from seven skin fold sites should be used in a quadratic, curvilinear equation to estimate body density to estimate body density, relative body fat, fat free mass (Pollock *et al*., 1984). Skin fold fat thickness measurement that use quadratic equation provide reasonably accurate estimates of total body fat or relative fat, with correlations ranging from .90 to .96 (Barrow & McGee, 1979) [1]. A different method of calculating body fat at home is circumference measuring (CM). With this technique, particular body parts are measured using a tape measure (Johnson & Nelson, 1986) [7]. These measurements are then entered into an equation to determine body fat percentage. CM is considered a reliable method to measure body fat (Johnson & Nelson, 1986) [7].

However, bioelectric impedance analysis (BIA) has some additional advantages over skin fold thickness method and circumference method while estimating the body fat percentage (Forde, 2015) [5]. Therefore the study aims to find out relationship of various circumference and skin fold methods of fat measurement techniques with bioelectrical impedance in Indian condition.

2. Objectives of the Study

1. To describe the specifics of each technique's data in order to understand its current situation.
2. To find out the relationship of various circumference method with Bioelectrical Impedance analysis for establishing the revalidation of the various circumference methods of fat measurement.
3. To find out the relationship of various skin fold methods with bioelectrical Impedance Analysis for establishing the revalidation of various skin fold method of fat measurement.
4. To compare the mean scores of body fat of the subjects calculated by various circumference and skin fold methods of fat measurement.

3. Materials and Methods

3.1 Participants

By using simple random sampling method, fifty (50) female students of hostels of Devi Ahilya University had been served as subjects for this study. The age range of the subject was between 18 to 26 years.

3.2 Measure

The following measurement techniques were chosen for revalidating in Indian condition.

Us navy circumference technique, (all measurement in cm) for women's

1. Fat % = 163,2058 x Log (Waist + Hip – Neck) – 97.684 x Log (Height) – 78
2. Fat % = 163.2058 x Log (Abdomen + Hip – Neck) – 97.684 x Log(Height) – 78

Skin Fold Technique for young women,

1. Lean body weight = 8.629 + 0.68 weight (kg) – 0.163 sub scapular skin fold (mm) – Triceps skin fold (mm) – 0.054 thigh skin fold (mm).
2. Lean body weight =1.661+0.668 weight (kg) + 0.555 neck circumference (cm) – 0.155 sub scapular skin fold (mm) - 0.81 triceps skin fold (mm) – 0.141 abdominal circumference (cm).

Circumference method Developed by Indu Taneja, For Young Women

1. Fat%= 0.1651× Weight (in kg) + .273 × buttocks (in inches) – 0.077 × Height (in cm) + 11.86
2. Fat % = 0.1651 x Weight (in Kg) + 0.1077 x Buttocks (in cm) – 0.077 x Height (in cm) + 11.86

3.3 Procedure

In circumference method a plastic with fiber glass freeman's standard measuring tape used lightly to the skin surface so that tape taught but not tight. The skin fold calliper (slim guide), which is manufactured of ABS plastic, is used to measure the thickness of a fold of skin and the fat layer beneath it. The skin fold caliper had springs, which exerts a certain pressure on the skin generally 10gm/mm2 and an accurate scale which measures the thickness in millimeters. The subjects stood in an easy and relaxed position and the right side of the body was used to determine the percentage of fat. The thickness of the skin and subcutaneous fat was grasped between the thumb and index finger and measurement was taken to the nearest millimeter from two different specific sites using the calipers which were required for the estimation of fat through regression equation. The supra iliac skin fold, triceps skin fold, sub scapular skin fold, thigh skin fold, abdomen skin fold, and biceps skin fold were all taken. With the aid of a Tanita body fat analyzer, the

subjects' respective body weights were recorded. To measure the height of all subject researcher marked reading on the wall and the subject stood barefooted with heels together and arms hanging naturally by sides.

4. Statistical analysis

For describing the characteristics of the data of various techniques of circumference and skin fold methods descriptive statistics applied. For comparing the fat measurement calculated through various techniques of circumference and skin fold methods and the criterion bioelectrical impedance one way analysis of variance statistics was applied (Field, 2009) [4] To establish the reliability, objectivity and validity of the instrument for estimating the fat percentage the level of significance was set at 0.05, which was considered adequate for the purpose of the study. SPSS 21 was used to analyze the data.

5. Results

As shown in table 1, Descriptive statistics of different fat percentage measuring techniques in which the mean of bioelectrical impedance analysis is 30.18, the standard deviation is 6.03. The overall mean and standard deviation show that the US Navy 2 approach is closer to the mean and standard deviation of the bio electrical impedance analysis, with a mean of 28.27 and a standard deviation of 7.04, respectively.

Table 1: Descriptive analysis of various fat measurement techniques

S.N.	Technique	Mean	SD	Min	Max
1	Bioelectrical Impedance Analysis	30.18	6.03	18.70	45.80
2	US Navy Technique, Method 1	25.34	7.11	10.90	43.03
3	US Navy Technique, Method 2	28.27	7.04	14.30	46.80
4	Skin Fold Technique, Method 1	26.27	3.66	17.13	33.53
5	Skin Fold Technique, Method 2	51.43	6.56	36.69	61.69
6	Circumference Method Developed by Indu Taneja, Formula 1	18.29	2.11	14.64	24.00
7	Circumference Method Developed by Indu Taneja, Formula 2	33.51	3.32	27.25	41.58

From table 2 of correlation coefficient between various fat measurement technique it is found that the correlation of us navy circumference method using abdominal circumference found higher than all measurement methods.

Table 2: Correlation coefficient between various fat measurement techniques with criterion

Criterion	Fat Measurement Technique	Coefficient of Correlation
Fat%	US Navy Circumference Method using Waist Circumference	0.931*
	US Navy Circumference Method Using Abdominal Circumference	0.936*
	Skin Fold Technique, Method 1	0.854*
	Skin Fold Technique, Method 2	0.648*
	Indu Taneja Circumference Method	0.946*
	Indu Taneja Circumference Method	0.929*

The figures clearly indicate that all methods are having a positive correlation but the skin fold method 2 scores are scattered widely. Also the validity cannot be decided on the basis of correlation so analysis of variance was applied to analyze the mean difference with the criterion which is presented in table 3.

Table 3: Analysis of Variance Table for Various Fat Measurement Techniques and Criterion

Source of Variance	Sum of Square	Df	Mean Sum of Square	F	Tab " F"
Between Groups	32278.958	6	5379.826	180.312*	2.13
Within Groups	10233.805	343	29.836		
Total	42512.763	349			

*significant at 0.05 level

"F" needed of significant at 0.05 level with df (6,343) = 2.13

From table 3, it is found that calculated "F" needed for significant at 0.05 level of are 2.13. Further which pair is having significant difference the L.S.D post hoc test was applied and the findings are presented in the table 4.

Table 4: Criterion Mean and Mean Difference between Criterion and Other Fat measurement Technique

Mean through Criterion (BIA)	Names of Other Fat Measurement Technique	Means of Fat % of Other Fat Measurement Technique	Mean Diff	Critical Difference
30.18	US Navy Circumference Method Using Waist Circumference	25.34	4.8428*	2.14
	US Navy Circumference Method Using Abdominal Circumference	28.27	1.9162	
	Skin Fold Technique, Method 1	26.27	3.9116*	
	Skin Fold Technique, Method 2	51.43	-21.2442*	
	Indu Taneja Circumference Method	18.29	11.8894*	
	Indu Taneja Circumference Method	33.51	-3.3252*	

*Significant at .05 level

"F" Needed of significant at .05 level with df (6,343) = 2.13

Table 4 clearly indicates that except the US navy method 2 all other fat measurement techniques have shown a significant mean difference with criterion. This indicates that the mean of us navy method 2 is as similar to the mean of criterion whereas other fat measurement techniques are having statistically different mean than the criterion**.**

6. Discussion

1. All fat measurement technique *viz*. circumference / skin fold are having a positive significant correlation with criterion i.e. Bioelectrical Impedance Analysis using Tanita Body Fat Analyzer.
2. Only US Navy Circumference technique, Method 2 (using Abdominal Circumference, Hip Circumference, Neck Circumference and Height) have shown an insignificant mean difference with criterion when ANOVA and LSD Post Hoc test was applied indicating that US Navy method 2 is very similar to criterion i.e. Bioelectric Impedance Analysis technique and the best circumference method for measuring body fat.
3. The mean value of Indu Taneja, Method 2 and Skin Fold, Method 1 are also closer to criterion and also having very high correlation with criterion i.e. Bioelectric Impedance Analysis technique but due to statistically significant mean difference with criterion these methods are not strongly recommended.

4. Instead of high correlation with criterion i.e. Bioelectric Impedance Analysis but due to very high and statistically significant mean difference the US Navy method 1, Indu taneja Method 1 and Skin Fold method 2 are not found a valid method for measuring body fat and therefore it is not recommended.

7. Conclusions

The above finding clearly indicates that in the two formulas for us navy method abdominal circumference instead of waist circumference is more suitable for measuring body fat for young Indian women. Waist circumference is considered the lowest measurement at the level of umbilicus (bellybutton). Taking waist measurement sometime create confusion to exactly find out the lowest measurement whereas measuring abdominal circumference the site is fixed in the line umbilicus. Also if the fat is deposited around the waist taking waist measurement which is less than the abdominal circumference might not suitable in Indian condition.

8. Acknowledgment

I would like to convey my heartfelt gratitude to prof. Ajay kumar sahani from school of physical education, Devi ahilya vishwavidyalaya, indore for his invaluable guidance and helpful advice and my peers Radha ninama, Aditi dalvi, Pratibha kaithwas, and Anjali gautam for providing technical assistance through-out the data collection for my study.

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