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Comparison of results between the equations of body fat assessment by Jackson & Pollock of four sites, seven sites skin folds and girth measurement

Dr. Brijesh T Varma[1], DR. Jayesh N Parmar[2]
[1] F.Y M.P.T. Student, Department of Physiotherapy, Government Physiotherapy College, Jamnagar, Gujarat, India
[2] Senior lecturer, Department of Physiotherapy, Government Physiotherapy College, Jamnagar, Gujarat, India

Abstract
Introduction: Obesity is a steadily growing epidemic affecting all segments of the population including college aged students. Assessment of body fat levels has increasingly assumed greater importance in recent years. The aim of the study was to compare the equations of body fat assessment by Jackson & Pollock of four sites, seven sites skin folds measurements and girth measurement.
Methods: Purposive sampling was used for selection of subjects. The sample was made up of 30 male subjects**.** The age of subjects ranged from 18 to 24 years. The data collected with the various methods on body fat measurement was analyzed by using paired t test. The level of significance was set at 0.05 for the study.
Results: Significant differences between JP7 and JP4, $p<0.0001$, were observed. Significant differences were observed between JP7 and girth measurement, $p<0.0001$ ($t=6.465$).
Conclusions: The analysis of data revealed that there was a significant difference among the body fat percentages measured with the Jackson and Pollock 7 sites vs 4 sites skin fold methods and Jackson and Pollock 7 sites skin fold method vs girth measurements.

Keywords: Body fat (BF), Body mass index (BMI), Jackson and Pollock, anthropometry, obesity, girth measurements, body composition, skin fold, generalized equation

Introduction

Excess accumulation of body fat represents a heterogeneous disorder in which energy intake chronically exceeds energy expenditure [1]. Assessment of body fat levels has increasingly assumed greater importance in recent years [2]. In addition, since with physical training, body fat can decline while muscle mass can increase, net changes in body weight cannot reliably predict body fat levels [3]. Most body composition analysis is based on seeing the body as consisting of two separate compartments, fat and fat-free. Obesity levels continue to increase across the lifespan with adults over 33% and children over 16% [4] Young adult gain significant amount of weight with majority of that weight being fat mass during 18-25 years of age, which is referred to as college aged [5]. College students generally have access to body mass index classification charts for the purpose of monitoring body mass changes, but BMI has shown to misclassify individuals and is not an accurate predictor of adipose tissue percentage.[6] Increase in the BMI through the range of moderate to severe is directly associated with the cardiovascular complication. We are now aware that excessive boy fat increases one's risk of developing a number of serious diseases, including coronary heart diseases, hypertension, stroke, chronic obstructive pulmonary disease, diabetes, arthritis, and some form of cancer, since, then a wide variety of methods have been developed. The direct method to measure the fat content of the human body is to dissect a cadaver, remove the fatty tissue, extract the fat with a solvent and weigh the extracted fat [7]. The indirect methods which is used to measure the fat of the human body includes hydrodensitometry, skin folds, girth measurements, x-ray, bioelectrical impedance analysis, ultrasound, computed tomography etc [1]. The cheapest and most common method to assess BF is skin fold thickness measure, which provide an estimate of the subcutaneous fat depot, recalculated for the total body fat or body density. The sites commonly used for skin fold measurements are: triceps, subscapular, iliac, abdominal, thigh, chest, bicep. Jackson and pollock gives the different formula to calculate the percentage of body fat like seven sites and three sites methods. Girth measurement offers an easily administered, valid and attractive alternative to skin folds. Along with the predicting percentage boy fat, girth measurement can also be used to analyze patterns of body fat distribution [1] The sites commonly used for girth measurements are: biceps, forearm, abdomen, hips, thigh and calf. Covert Baily and Katch & Katch gives the formulae to calculate the percentage of fat from the girth measurement. Nowadays monitoring body composition is very necessary. The skin-folds and girth measurement are widely used by fitness professionals to estimate both body density and body fat percentage. Jackson and Pollock's seven sites formula had a correlation of. 915 when compared to hydrostatic weighing to estimate body density. The standard error of estimate was 0.008 expressed in body density and a standard error of estimate of 3.5 when expressed in % BF using equation by Siri. Loenneke *et al*. 2014 demonstrated significant differences between jackson-

pollock three sites and one site bicep methods when compared with DXA in estimating % body fat in a population of female college gymnasts [8] The Jackson and Pollock generalised equation validation research has been cited over 1300 times in the scientific literature and men's study was reproduced in 2004 as a British Journal Of Nutrition citation classic [9, 10, 11]. Margotl T *et al*. 2009 stated that there is no significant difference between jackson-pollock three and seven sites methods in estimating % body fat in male and female [12]

AIM: to compare the equations of body fat assessment by Jackson & pollock of four sites, seven sites skin folds measurements and girth measurement.

Hypothesis

Null Hypothesis

There is no significant difference between jackson-pollock seven sites, four sites skin fold methods and girth measurement method to estimate % of body fat in humans.

Alternate hypothesis

There is significant difference between jackson-pollock seven sites, four sites skin fold method and girth measurement method to estimate % of body fat in humans.

Objectives

To define the variation in fat percentage between the two equations of jackson- pollock.

To define the variation in fat percentage between the skin folds method and girth measurement method.

Methods

Skin fold measurement

Measuring skin fold thickness requires firmly grasping a fold of skin and subcutaneous fat with the thumb and forefingers, pulling it away from the underlying muscle tissue following natural contour of the skin fold. When calibrated the pincer jaws exerts a relatively constant tension of 10 g. mm^{-2} at the point of contact with the double layer of skin plus subcutaneous adipose tissue. A SAEHAN skin fold caliper was used to measure the skin fold. The caliper dial indicates skin fold thickness in millimeters (mm), recorded within 2 seconds after applying full force of the caliper. This time limitation avoid skin fold compression when taking the measurement [1].

Measurements sites

1. Triceps**:** Vertical fold between the posterior midline of the right upper arm, halfway between tip of the shoulder and the tip of the elbow
2. Sub scapular**:** Oblique fold just below the bottom tip of the right scapula
3. Iliac**:** slightly oblique fold just above the right hip bone
4. Abdominal**:** vertical fold 1 inch to the right of the umbilicus
5. Thigh**:** Vertical fold at the midline of the right thigh
6. Chest**:** Diagonal fold with long axis directed toward the right nipple
7. Biceps: Vertical fold at the posterior midline of the right upper arm.

Girth measurements

Apply a linen or plastic tape lightly to the skin surface so the tape remains taut but not tight. This avoids skin compression, which produces below normal scores.

Measurement sites

1. Right upper arm (Biceps): Arm straight and extended in front of the body, measurement taken at the midpoint between shoulder and the elbow.
2. Right forearm:-Maximum girth with arm extended in front of the body.
3. Abdomen**:** 1 inch above the umbilicus
4. Buttocks:-maximum protrusion with heels together.
5. Right thigh**:**-upper thigh, just below the buttocks.
6. Right Calf**:**-widest girth midway between ankle and knee.

Jackson and Pollock 4 sites body fat formula for men

BD= (0.29288*sum of skin fold)-(0.0005*square of sum of skin folds)+(0.15845*age)-5.76377

%BF= (495/BD)-450

Abdominal, tricpe, thigh and suprailiac.

Jackson and Pollock 7 sites body fat formula for men

BD=1.112-(0.00043499*sum of skin folds) + (0.0000055*square of sum of skin folds)-(0.00028826*age)

Chest, axila, triceps, subscapular, abdominal, suprailiac and thigh Katch and Katch body fat formula for men (17-26) yrs

%BF= (upper arm*3.70) + (abdominal*1.31) - (forearm*5.43) -10.2 (or 14.2)

Statistical analysis

A paired sample t test for the total sample were perform between JP7 and JP4, JP7 and Girth measurement, JP4 and Girth measurement with 95% confidence intervals. Acceptable statistical significance was set at $p< 0.05$ for test. Statistical analyses were performed using SPSS (version 19).

Results

Table 1: descriptive stastistics of the fat percentage measured with selected fat measurement methods

	N	Mean	SD	Std Error	Minimum	Maximum
%BF 7 Sites	30	15.670	5.402	0.986	6.916	25.808
%BF 4 Sites	30	16.939	5.923	1.081	6.953	26.794
%BF Girth Measurement	30	11.597	6.720	1.226	1.455	27.525
Total	90	14.735	6.015	1.097	5.108	26.709

Table 1: indicates that mean of fat percentage with JP7, JP4 and Girth measurement is 15.6, 16.6, and 11.595 respectively. However, SD of fat percentage with JP7, JP4 and Girth measurement is 5.4, 5.9, and 6.7 respectively. This reflects that JP4 sites skin fold method and Girth measurement method over estimate percentage of body fat as compare to JP7 skin fold method. Figure 1: indicates that the maximum value of fat percentage with JP7, JP4, and Girth measurement is 25.8, 26.7, and 27.2 respectively. This also reflects that JP4 sites skin fold method and Girth measurement method over estimate percentage of body fat as compare to JP7 sites skin fold method.

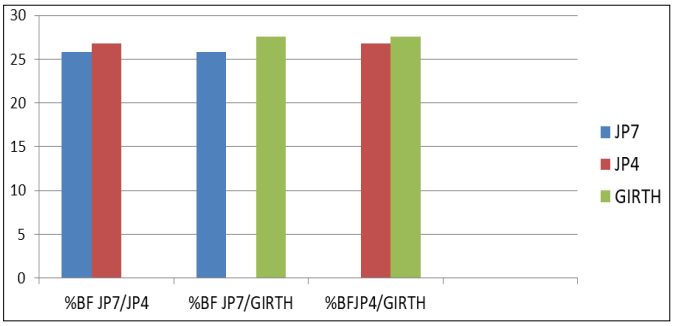

Fig1: Comparing percentage of bf between jp7/jp4, jp7/girth & jp4/girth by condition p* < 0.05

Table 2

	%BF	t	P
Pair 1	MAX	7.0493	0.0001
JP 7 sites skinfolds	25.808		
JP 4 sites skinfolds	26.794		
PAIR 2		6.465	0.0001
JP 7 sites skinfolds	25.808		
Girth measurements	27.525		
Pair 3		8.1116	0.0001
JP4 Sites Skinfolds	26.794		
Girth Measurements	27.525		

Paired Sample T Test Comparing Jp7 Vs Jp4, Jp7 Vs Girth Measurement & Jp4 Vs Girth Measurement

JP7= percentage of body fat using Jackson and Pollock seven site equation, JP4= percentage of body fat using Jackson and Pollock four site equation, %BF= percentage of body fat, $p<0.05$.

A paired sample t test revealed significant difference between %BF using the JP7 equation and JP4 equation $t=7.0493$, $p<0.0001$. However, significant difference was observed between JP7 equation and Girth measurement equation $t=6.465$, $p<0.0001$. Additionally, significant difference was observed between JP4 site equation and Girth measurement equation $t=8.1116$, $p<0.00$.

Discussion

It was hypothesized that using the JP4 site skin fold method and Girth measurement method to estimate percentage of body fat would reflect highly significant difference when compared to a seven site Jackson and Pollock manufacturer developed equation. Our findings showed JP4 site skin fold method and girth measurement method over estimate the percentage of body fat when compared to Jackson and Pollock seven site skin fold equation. Lhachmi *et al*, 2013: found that Jackson and Pollock three site method underestimate percentage of body fat when compared with dual energy X-ray absorptiometry (DXA).13 Johnson *et al*, 2014: found ultrasound to underestimate average body fat percentage in college age individuals using seven measurement sites when compared with DXA.14 Our result found the max value of body fat percentage Jackson and Pollock 4 site to be higher, 26.794%, than that of Jackson and Pollock seven site, 25.808. We also found that max value of body fat percentage Girth measurement to be higher, 27.252%, than that of the Jackson and Pollock seven site, 25.808. Based on that assumption JP4 site skin fold method and Girth measurement method over estimates percentage of body fat when compared to Jackson and Pollock seven site equation. Marissa N. Baranauskas *et al*, 2015 performed a study "Seven site versus three site method of boy composition using body matrix ultrasound compared to DXA" and found significant difference among JP7 site, Pollock three site and JP3 site compared to DXA in estimation of percent adipose tissue ($p<0.001$) which may be reflective of a problem of total averaged measurement sites or algorithms rather than ultrasound device inaccuracy.15 Another study had been performed by Tarcisio Margoti *et al*. 2009 where he compared the equations of body fat assessment of JACKSON & POLLOCK of three sites and seven site skin fold with 99% confidence in male and female samples and concluded that there is no significant difference between the result of the Jackson and Pollock three site skin fold method and Jackson and Pollock seven site skin fold method which is not supporting the result of this study ($Z=0.34$).13

Conclusion

Many methods are available for fat prediction but in sports and fitness industry mostly noninvasive methods are preferred as they are quick and reliable. From this study we concluded that JP7 site skin fold method is more accurate and reliable as compared to JP4 site skin fold method and Girth measurement method and should be used for fat assessment in future.

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Conflict of Interest

There was no personal or institutional conflict of interest for this study.

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