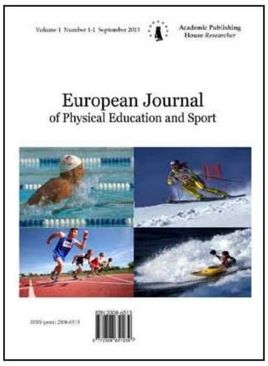
Published in the Russian Federation
European Journal of Physical Education and Sport
Has been issued since 2013.
ISSN: 2310-0133
E-ISSN: 2310-3434
Vol. 13, Is. 3, pp. 103-107, 2016

DOI: 10.13187/ejpe.2016.13.103
www.ejournal7.com



Models in Estimating Fat Percentage in Active Male

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Abstract

This study was undertaken to develop different predictive models for the active college males in the age range of 18–24 years. The reference variable was the fat percentage measured with bio-electrical impendence. Five sets of independent models were generated with girth alone, skinfold alone, girth with demographic, skinfold with demographic and all together. Step-wise multiple regression was carried out in each category of variables and the best model from each category was identifies and compared. The analysis revealed that the best model evolved when all the variables were used with a R^2 value of 0.797. The model with girth and demographic variables resulted in R^2 of 0.793. Since girth is easier to measure, the second model may be used for the estimation in field situation. However, the model demands validation in a larger population.

Keywords: Fat percentage, Estimation, Regression.

1. Introduction

Fat is an essential component of human body that supplies energy and nutrients for proper functioning of different body parts. This also acts as a source of essential fatty acids required by the body (Ainala et al., 2015). However, excess fat is also harmful for the body. Excessive fat leads to the condition of 'Obesity' which is associated with a variety of metabolic disturbances and long-term cardiovascular complications. The global obesity epidemic has become a menace to the society (Chan and Nelson, 2009; Lohman, et al., 2000). Thus for the implementation of curative and preventive health measures, the assessment of fat percentage is very essential (Ranasinghe et al., 2013).

Hydrostatic weighing has long been considered the "gold standard" for estimating body fat. The requirement of specialised equipment and trained technicians has resisted its use in field situation and alternative methods were developed using body anthropometry (Kujawa et al., 2002). Valid determinations of body fat percentage is possible using skinfold callipers in men (Jackson and Pollock, 1978) and women (Jackson et al., 1980) with multiple correlations, to underwater weighing, exceeding 0.90 in men and ranging from 0.842 to 0.867 in women. Jackson et al (1980) reported that body composition determined using skinfolds was strongly correlated (r=0.82) with body fat determined using underwater weighing. Skinfold determination can be made using several different equations, including a three-site, four-site, or seven-site skinfold formula (Jackson and Pollock, 1978). However, this also requires expertise and availability of calibrated callipers. So, in order to make the measurements more practical and field oriented several other measures have also been formulated using girths such as BMI, waist to hip ratio, etc. (Howley and Thompson, 1943).

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Ballor and Katch (1989) mentioned that the accuracy of anthropometric prediction equations dependents on many factors including age, gender, body composition status, and statistical considerations (Katch and McArdle, 1973; Katch and Katch, 1980; Lohman, 1981; Pollock et al., 1975). The present study aimed at developing several regression equations for predicting the fat % of Indian active population and compares the effectiveness of the models in the age range of 18 to 24 years on the basis of skinfold, girth, skinfold with demographics, girth with demographics and all types of combined variables.

2. Materials and Methods

In developing regression equations the fat percentage was considered as the dependent variable and bodily measurements were the independent variables. Thirty eight healthy adult male subjects were randomly chosen from the Lakshmibai National Institute of Physical Education Gwalior in the age range 18–24 years with sporting background as a sample for the study. The consent from the individuals was obtained before proceeding for measurements.

Seven bodily circumferences namely, Neck, Biceps, Chest, Waist, Hip, Thigh, Calves and Forearms were measured with tape and the data was recorded in centimetres. Further, seven skinfolds namely, Triceps, Suprailiac, Thigh, chest, Abdomen, Axilla and Subscapular was measured with Harpender calibrator (British Indicators Ltd, Luton, UK) with 0.1 mm precision and constant pressure of approximately 10 g/mm^{2}was used for the measurement of the skinfolds. All measurements were taken three times on the right side of the body and the mean values were used for the calculations.

Weight and Height of the subjects were also recorded with a calibrated weighing scale and stadiometer respectively using standard methods. The Fat percentage was obtained from the TANITA BC-420MA Leg-to-Leg Bio Impedance Machine. The instrument has reliability greater than 0.80 and is also considered valid in the medical community (Tanita, 2015; Kutac et al., 2008; Jebb et al., 2007).

3. Results

The stepwise multiple regression was applied separately on the data of Demographic variables, Girths, skinfolds, girths & demographic, skinfold & demographics and all together using SPSS® 20. Except "skinfolds alone" group, in all other categories more than one model could be developed. Table 1 show different models developed in each combination of variables.

Table 1. Summary of all the derived models

	R	R^2	Adj. R^2	SEE	Variables in the model
Skinfold and Demographic	**0.868**	**0.754**	**0.732**	**2.508**	**(Constant), Axilla Skinfold, Weight, Height**
Skinfold and Demographic	0.836	0.699	0.682	2.733	(Constant), **Axilla** Skinfold, Weight
Skinfold and Demographic	0.798	0.637	0.627	2.961	(Constant), **Axilla** Skinfold
Skinfold	**0.798**	**0.637**	**0.627**	**2.961**	**(Constant), Axilla Skinfold**
Girth and Demographic	**0.890**	**0.793**	**0.774**	**2.302**	**(Constant), Hip Circumference, Weight, Height**
Girth and Demographic	0.860	0.74	0.725	2.543	(Constant), Hip Circumference, Weight
Girth and Demographic	0.785	0.616	0.606	3.044	(Constant), Hip Circumference
Girth	**0.854**	**0.729**	**0.714**	**2.594**	**(Constant), Hip Circumference, Thigh Circumference**
Girth	0.785	0.616	0.606	3.044	(Constant), Hip Circumference
All Together	**0.893**	**0.797**	**0.779**	**2.280**	**(Constant), Axilla Skinfold, Hip Circumference, Neck Circumference**
All Together	0.873	0.762	0.749	2.430	(Constant), Axilla Skinfold, Hip Circumference
All Together	0.798	0.637	0.627	2.961	(Constant), Axilla Skinfold

NB: The model with highest R^2 value in each category has been marked in bold.

The best model was obtained when all the variables were taken in the analysis, with R^2 value of 0.797 having predictors as axilla skinfold, hip circumference and neck circumference. The second best model was obtained in the 'Girth and demographic' variable with R^2 of 0.793 and the predictor variables as Constant, Hip circumference, Weight and height. There exists a very marginal difference in the percentage variance explained (R^2) by the top two consecutive models. The least variance is explained by the model in skinfold alone group with a R^2 of 0.637.

Table 2. Coefficients of the predictor variables included in the best model of each combination

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
All Together	(Constant)	-31.318	7.906		-3.961	0.000
	Axilla skinfold	0.458	0.109	0.438	4.2	0.000
	Hip circumference	0.609	0.182	0.365	3.339	0.002
	Neck circumference	1.409	0.587	0.236	2.398	0.022
Girth and Demographic	(Constant)	5.151	12.657		0.407	0.687
	Hip circumference	0.636	0.182	0.381	3.498	0.001
	Weight	0.355	0.066	0.675	5.378	0.000
	Height	-0.209	0.071	-0.282	-2.952	0.006
Skinfold and Demographic	(Constant)	26.392	11.431		2.309	0.027
	Axilla skinfold	0.344	0.155	0.329	2.223	0.033
	Weight	0.354	0.089	0.674	3.989	0.000
	Height	-0.218	0.079	-0.294	-2.746	0.010
Girth	(Constant)	-39.652	5.606		-7.073	0.000
	Hip circumference	1.197	0.15	0.717	7.982	0.000
	Thigh circumference	0.527	0.138	0.343	3.814	0.001
Skinfold	(Constant)	7.186	1.041		6.904	0.000
	Axilla Skinfold	0.834	0.105	0.798	7.946	0.000

The following equations were derived using the unstandardized coefficients for selected combination of variables:

Equation 1 (R^2= 0.893):

Fat % = - 31.318 + 0.458(Axilla skinfold) + 0.609(Hip circumference) + 1.409(Neck circumference)

Equation 2 (R^2= 0.890):

Fat % = 5.151 + 0.636(Hip circumference) + 0.355(Weight) – 0.209(Height)

Equation 3(R^2= 0.868):

Fat % = 26.392 + 0.344(Axilla skinfold) + 0.354(Weight) – 0.218(Height)

Equation 4 (R^2= 0.854):

Fat % = -39.652 + 1.197(Hip circumference) – 0.527(Thigh circumference)

Equation 5 (R^2= 0.798):

Fat % = 7/186 + 0.834(Axilla skinfold)

As equation 5 holds the lowest R^2, it should be avoided for estimating fat percentage.

4. Discussion

Fat estimation methods based on anthropometric variables aims at finding valid representative of fat and in this process, the present study ended up with five equations using girth measurements, skinfold measurement, girth with demographic variables, skinfold with demographic variables and all the variables together. The best equation evolved from the model developed by exploring all the variables together with a R^2 of 0.797 and a standard error of 2.280. Out of all 17 variables only three variables namely axilla skinfold, hip circumference and neck circumference were retained. The second best model with R^2 of 0.793 and a standard error of 2.594 was derived from the girth (Hip circumference) and demographic variables (Height & Weight). According to Kujawa et al. (2002) one of the major source of error in measurement of fat is the technical error made during the measurement of anthropometric segments. The circumferences can be measured more precisely than skinfolds (Roche, 1996), which has the effect of decreasing the proportion of error in predicting body fat percentage due to measurement of the anthropometric variables. It has also been shown that individuals can learn to measure circumferences accurately, more quickly and more easily than skinfolds (Heaney, 1998). Thus, the second model can be best utilised for the prediction of fat percentage. Jackson et al. (1980) gave four predictive models with Sum 4SF, Sum 4SF+C, Sum 3SF, Sum 3SF+C with a R^2 value of 0.85, 0.86, 0.84 & 0.85 respectively. These equations had higher R^2 value but they were constructed on children and youths of normal population. The lower R^2 value in the present study indicates the inclusion of some other factors than those of selected in the present study.

The study found the existing fat percentage estimation models inadequate for active population as it retained only axilla skinfold during the development of model using skinfolds only. The principle of fat percentage estimation through anthropometric measurements lies in the measurement of subcutaneous fat. Since active youths are regularly engaged in exercise the accumulation of subcutaneous fat vary from the normal sedentary population. Further, the earlier equations are composed of sum of skinfold and individual skinfolds have been seldom evaluated for their significance. Also axilla skinfold which has been identified in the model as a significant predictor does not figure in many popular models (Ballor and Katch, 1989)

It is quite significant to note that demographic variables (Height and Weight) were included in the model when it was developed using variables in the Girth and Skinfold group, but were excluded when the model was developed using all the variables. Thus, it prompts for the inclusion of height and weight in the predictive models for the calculation of fat percentage using skinfolds measurements but all the popular models mentioned by Jackson et al. (1980) lacks these two parameters. The exclusion of age as predictor in all the models demonstrates the stabilization of the effect of age and the directive for the usage of the equations throughout the age range of 18–24 years. Out of all the included variables the height holds a negative coefficient, indicating a decrease in fat % with increase in height for a given value of other predictor variables.

5. Conclusion and recommendations

In the absence of any prediction model for the active population, any of the first four models developed in the study can be used for the fat percentage estimation. The second model i.e. Fat % = 5.151 + 0.636(Hip circumference) + 0.335(Weight) – 0.209(Height) is the best suitable in field situations as it includes only one girth measurement along with Height and Weight. These variables can be measured with less competency and error and would enhance the reliability in the study. However, these models need to be validated in large population before any clinical evaluation.

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