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Prediction of basal metabolic rate on the basis of body composition variables and obesity indicators in physically active postmenopausal women

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Abstract
The aim of the study was to establish regression equation for predicting Basal Metabolic Rate on the basis of Body Fat, Lean Body Mass, Body Mass Index, Waist Circumference, Waist Hip Ratio, Total Body water. Further to find out correlation between selected Independent variables (Body Fat, Lean Body Mass, Body Mass Index, Waist Circumference, Waist Hip Ratio, Total Body water) with Dependent Variable (Basal Metabolic rate), to study the joint contribution of Independent Variables in estimating Basal Metabolic rate. Fifty postmenopausal women, of different colleges and universities of Bilaspur and Raipur, Chhattisgarh, India, age ranged from 45 to 65 were selected for this study. To find out correlation between Independent Variables and Dependent Variable, and joint contribution of Independent variable in estimating Dependent Variable, Product Moment Method of correlation and multiple correlations was used. Regression equation (Enter method) was established for predicting Dependent variable on the basis of Independent variables. It exists a significant relationship between Body Fat, Lean Body Mass, Total Body water, Waist circumference, Waist hip ratio. In regression model, the value of R2 [0.611 (BFT, LBM, TBW, WC& WHR)] developed for prediction of Basal Metabolic Rate. The resulting regression equation is: Basal metabolic rate = 1.867 (BFT) + 7.818 (WC) +694.447(WHR) +8.360(LBM) +.396(TBW) -.912(BMI) - 362.662.The equation estimates that for the sample survey 61.1% of the variation in Basal metabolic rate is explained by the body's waist circumference and lean body mass. Also, the significance value for Waist circumference (.001), Lean body mass (.025), was less than 0.05. And the null hypothesis, that there will be no linear relationship between predictors and Basal metabolic rate could not be accepted.

Keywords: Prediction, basal metabolic, postmenopausal women

Introduction
Basal metabolic rate (BMR) is the largest component of daily energy demand in Western societies. Previous studies indicated that BMR is highly variable, but the cause of this variation is disputed. All studies agree that variation in fat-free mass (FFM) plays a major role, but effects of fat mass (FM), age, sex, and the hormones leptin, triiodothyronine (T3), and thyroxine (T4) remain uncertain. Basal metabolic rate is expressed as calories per unit of body surface area. There are many factors affecting BMR. It includes age, sex, and pregnancy. Other factors that increase BMR are intake of diet, increased secretion of certain hormones, increased physical exercise, environmental conditions, increased stress and anxiety. Other factors that decrease BMR are malnutrition, fasting, sleep. Fat free mass or Lean body mass is the major factor which determines basal metabolic rate**.** It is important to understand the physiologic nature of this variability as it has been led to the disease named "Obesity" in 2 separate ways.

The major factor determining basal metabolic rate (BMR) is fat-free mass (FFM) (Weinsier, Schutz, Bracco, 1992; Cunningham, 1991; Fukagawa, Bandini, Young, 1990) [12, 19, 20, 4, 5, 6, 7], with some studies finding an additional contribution of fat mass (FM) (Nelson, *et al*, 1992; Svendsen, Hassager, Christiansen, 1993) [12, 16], but others failing to find such an effect (Bogardus, 1986; Segal, 1987) [3, 15]. Even when these factors are known, however, substantial residual variation remains. Understanding the physiologic nature of this variability is important because it has been implicated in the obesity epidemic in 2 separate ways. First, low

BMR (after mass effects are removed) may be a predisposing risk factor for the development of obesity (Roberts, *et al*, 1988; Ravussin, *et al*, 1988) [14], and cross-sectional studies often report that formerly obese subjects have BMRs that are 3–5% lower than expected (Astrup, *et al.*, 1999). A primary conclusion of The International Dietary Energy Consultancy Group workshop on energy and protein requirements in 1994 (Scrimshaw) was that "There is a need to investigate the causes of the relatively large inter-individual variations in BMR." Despite this need being identified a decade ago, however, little progress has been made. SM Haffner and JP Despres *et al.* conducted study on abdominal adiposity and cardio metabolic risk and metabolic syndrome respectively and have revealed that independent of total amount of adipose tissue, excess adipose tissue in the abdomen, especially around visceral organs, increases metabolic risk of cardiovascular disease (CVD).

Objective of the study
1. The objective of the study was planned with the aim to find out coefficient correlation between Dependent variable (Basal Metabolic Rate) and Independent variables (Body Fat, Body Mass Index, Lean Body Mass, Water (lit), Waist Circumference, Waist Hip ratio).
2. To study the joint contribution of Independent Variables in estimating Dependent Variable.
3. To establish regression equation for predicting Dependent Variable on the basis of Independent Variables.

Methodology
Selection of Subjects
Fifty (50) physically active postmenopausal were selected from different colleges, schools and universities of Bilaspur and Raipur. Age of the subjects was ranging between 45 to 65 years. All subjects were in the postmenopausal stage. Also the subjects were not sedentary, they were physically active.

Selection of Variables
Keeping the feasibility criterion in mind, the researcher selected the following body composition variables and obesity indicators for the present study:

Independent Variables
- Body Fat.
- Body Mass Index.
- Lean Body Mass.
- Total Body Water.

Obesity Indicators
- Waist Circumference.
- Waist Hip Ratio.

Dependent Variables
Basal Metabolic Rate (BMR).

Criterion Measures
- The scholar under the guidance of the expert conducted the present study and callipered instruments were used. The Basal Metabolic Rate was measured in early morning with the help of Maltron BF907 "Body Composition Analyzer". The data was collected in empty stomach before the actual involvement of the subject in physical activities.
- The demographic data was collected one day before the testing, where the subjects were informed regarding the precautions to be taken before testing. The subjects were asked to remain in lying position for 15-20 minutes prior to testing.
- Waist Circumference (WC) and Hip Circumference (HC) were measured with an anthropometric tape (Lufkin EXECUTIVE THINLINE) with minimal clothing, at the minimum circumference between the iliac crest and the rib cage, and at the maximum protuberance of the buttocks. Then WHR was calculated as WC divided by HC.

Statistical Analysis
For determining relationships of BMR with body composition variables and obesity indicators, descriptive statistics and the Pearson's Product Moment Correlation was used, the data analyzed with the help of SPSS (16.0 version) software and the level of significance was set at 0.05 level of confidence.

Result and Findings of the Study

Table 1: Mean and SD Values of Basal Metabolic Rate and Selected Independent Variables

Variable	BMR (KCL/DAY)	BFT (KG)	BMI (KG/CM^2)	LBM (KG)	Total Body Water (KG)	WC (cm)	WHR
MEAN	1176.6E3	25.97	25.78	41.12	29.77	76.44	0.80
S.D	90.56	4.04	2.56	4.14	4.11	4.53	0.026

BMR=Basal Metabolic Rate, BFT= Body Fat Mass, BMI=Body Mass Index, LBM=Lean Body Mass, WATER= Water (lt.), WC= Waist Circumference, WHR = Waist Hip Ratio.

Table 2: Correlation between Dependent Variable (Basal Metabolic Rate) and Independent Variables (Total Body Water, Body Fat, Lean Body Mass, Waist Circumference, Waist Hip ratio)

Variables	Correlation Coefficient	Sig. value
Body fat %	.422	.001
BMI	.420	.001
WC	.606	.000
WHR	.507	.000
LBM	.622	.000
WATER	.433	.001

Table 3: Model Summary along with the multiple correlation and R^2 of BFT, BMI, LBM, TBW, WC and WHR in predicting Basal Metabolic Rate.

Model	R	R^2	Adjusted R^2	Std. Error of the estimate
1	.781^a	.611	.556	60.32

a. Predictors (constant), Body mass index, Body fat, Lean Body Mass, Total body water, Waist circumference, Waist hip ratio.

The above table showed that $R^2$was found. 611 considering Body Fat, Lean Body Mass, Body mass index, Total Body Water, Waist circumference and Waist hip ratio as predictors which was included in enter method, which means that 61.6% of the variance in Basal Metabolic Rate was associated with body composition variables and obesity indicators.

Table 4: ANOVA Table

Model	Sum of squares	Df	Mean square	F	Sig.
Regression	245405.064	6	40900.844	11.241	.000[a]
Residual	156462.456	43	3638.662		
Total	401867.520	49			

a. Predictors (constant), Body mass index, Body fat, Lean Body Mass, Total body water, Waist circumference, Waist hip ratio.

ANOVA tests the null Hypothesis that there was no linear relationship between BMR and Body composition variables and obesity indicators in physically active postmenopausal women. For the Model I in above table, the significance level associated with observed value of F (11.24) was founder greater than the tabulated value. Thus, the null hypothesis could be rejected and we may conclude that there was a significant linear relationship between Basal Metabolic Rate and Independent variables.

Table 5: Regression coefficient of selected variables in predicting Dependent variable (Basal Metabolic Rate)

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	-362.662	275.898		-1.314	.196
Body fat	1.867	2.567	.083	.727	.471
Waist circumference	7.818	2.198	.392	3.557	.001
Waist hip ratio	694.447	373.512	.203	1.859	.070
Lean body mass	8.360	3.605	.383	2.319	.025
Total body water	.396	3.374	.018	.117	.907
Body mass index	-.912	4.179	-.026	-.218	.828

a. Predictors (constant), Body Fat, LBM, BMI, WC AND WHR.

The above table displayed the value of the coefficient in the regression equation and measures the probability that a linear relationship existed between Basal Metabolic Rate and the independent variables. In this table 'B' was the slope of line.' SE B' was the standard error of 'B'. Beta was the standardized regression coefficient. 'Sig' was the significance level for the test of the null hypothesis that the value of a coefficient was .005 in the population.

In model I, the significance value for Waist circumference (.001), Lean body mass (.025), was less than0.05.Therfore, the null hypothesis, that there will be no linear relationship between predictors and Basal metabolic rate could not be accepted.

The resulting regression equation is:

Basal metabolic rate = 1.867 (BFT) + 7.818 (WC) +694.447(WHR) +8.360(LBM) +.396(TBW) -.912(BMI) - 362.662.

The equation estimates that for the sample survey 61.1% of the variation in Basal metabolic rate is explained by the body's waist circumference and lean body mass.

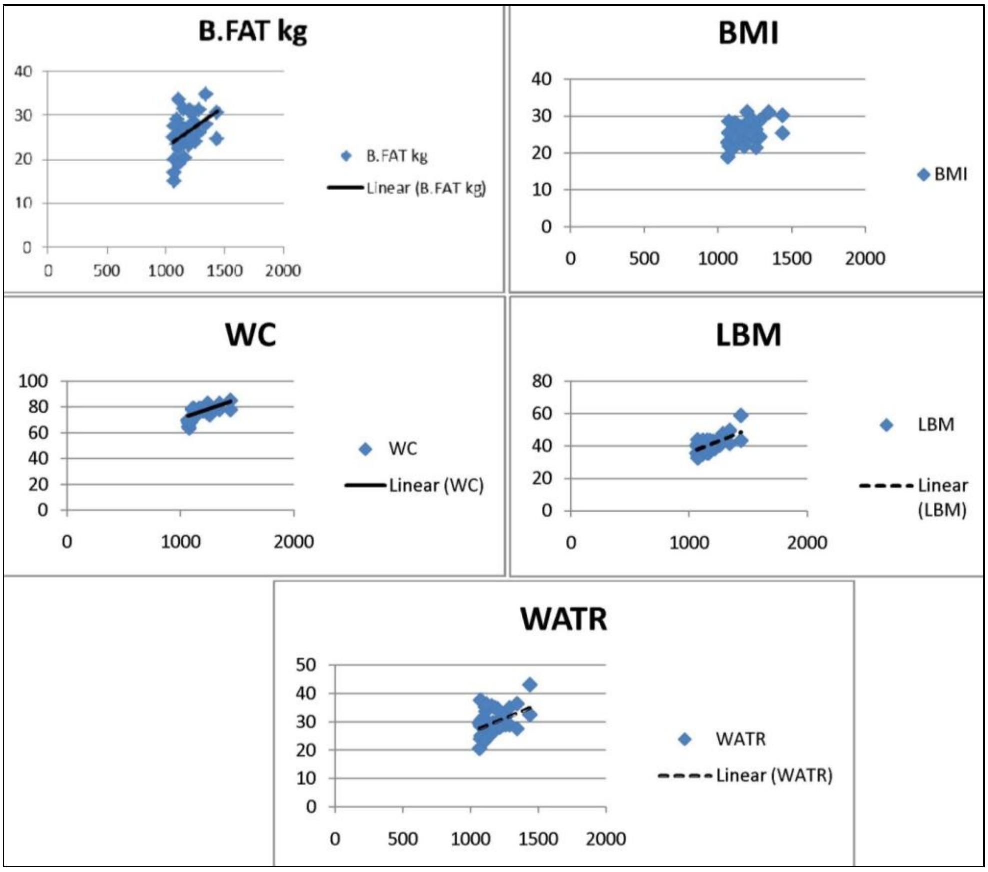

Fig 1: Scatter diagram shows relationship between BMR and Body Composition Variables.

Discussion

The objective of the study was to find the correlation between Basal Metabolic Rate and Body composition variables and obesity indicators. The results show that 61.1% of variance of Basal Metabolic Rate is associated with Body composition variables and obesity indicators. There is a significant relationship between Body Fat Percentage and Body Mass Index ($p<0.05$) BMR. Also, there is a significant relationship of Waist circumference, Waist hip Ratio and Lean Body Mass ($p<0.05$) with BMR.

Basal metabolic rate is expressed as calories per unit of body surface area. As said there are many factors such as age, sex, pregnancy, intake of diet, increased physical exercise, environmental conditions, increased stress and anxiety. The study indicates the significant relationship between LBM ($p<0.05$) and BMR**.** Kleiber *et al.* (1975) [8] stated that Fat free mass or Lean body mass is the major factor which determines basal metabolic rate but studies by Weinsier depict additional contribution of fat mass to basal metabolic rate. Also, studies by Benedict (1915) [2] supports stating that active body mass determines BMR is supported. Even though various factors affect Body composition (such as age, sex) but it is the principle determinant of BMR.

The sample for the study were physically active post-menopausal women, which was the probable reason for significant relationship of waist circumference with BMR (r=0.001).Increased BMI, which is associated with numerous health problems predictive of increased risk of CVD and other chronic diseases, is well known in women at menopause. Waist circumference has direct relationship with waist hip ratio due to which Waist Hip Ratio showed a significant relation with BMR. Significant values of Lean Body Mass would be a probable reason for significant relationship of water content with BMR of postmenopausal women. Also, the subjects were physically active which would be an added factor.

Conclusion

The study concludes that there exists a linear relationship between Basal Metabolic Rate (Dependent Variable) &Body composition variables and Obesity Indicators (Independent Variable). Through Multiple Relation(R) the study also shows that 61.6 % (R^2 =.661) of the variance in Basal Metabolic Rate was associated with body composition variables and obesity indicators. The regression equation established were as follows: Basal metabolic rate = 362.662 + 1.867 (BFT) + 7.818 (WC) +694.447(WHR) +8.360(LBM) +.396(TBW) - .912(BMI).

The study concludes depicting the significance of following variables:

a. Significant relationship was found between Body fat % and BMR (r= 0.422, $p<0.01$).
b. Significant relationship was found between Body Mass Index and BMR (r=0.420, $p<0.01$).
c. Significant relationship was found between Waist circumference and BMR (r=0.606, $p<0.01$).
d. Significant relationship was found between Waist Hip Ratio and BMR (r=0.507, $p<0.01$).
e. Significant relationship was found between Lean Body Massand BMR (r=0.622, $p<0.01$).
f. Significant relationship was found between Water content and BMR (r=0.433, $p<0.01$).

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