

# Estimation of Calorie Deficit (CD) by Assessing the Energy Parameters and Physical Activity Level (PAL) in Overweight Indian Women

Swapan Banerjee\* and Sulagna Ray Pal

Department of Nutrition, Seacom Skills University, Kendradangal, Birbhum - 731236, West Bengal, India; sbanerjee.researcher.21@gmail.com

## Abstract

Calorie (Kcal) reduction or deficit calculations for those who are overweight or obese lack a clear set of rules, an equation, or a theory in the literature. Although recommendations to cut caloric intake by up to 500 kcal per day have been made in Western countries. Additional research is needed to support energy consumption and expenditure. The difference between estimated Total Energy Expenditure (TEE) and Daily Energy Expenditure (DEE) is what this research article calls the “cutting value” of daily energy for an overweight or obese woman. The study found that using multiple regression analysis,  $r$  as correlation coefficient = 0.839 (‘good fit’ as close to 1),  $R^2 = 0.704$  (reliable). The  $p$ -value is less than .001, indicating that the model is highly statistically significant ( $p < 0.05$ ). The study concludes that an effective formula for finding Calorie Deficit (CD) with low error can help researchers with further research. More importantly, dietitians can also recommend near-to-correct kilocalories reduction to an overweight or metabolic syndrome patient using this simple formula.

**Keywords:** Calorie Deficit, Calorie Restriction, Calorie Management, Energy Components, Obesity Diet

## 1. Introduction

Food is the source of energy in the living world. Energy intake and expenditure depend on body composition, body size, and the consistent health status of an individual. A drastic transformation of lifestyles has been observed, particularly among the urban population, including women, in a few decades. More calorie-dense food consumption and insufficient exercises (active energy expenditure) is almost widespread, even in a large population of middle-aged women. By daily activities, three activities-based groups are categorized as sedentary, moderate, and heavy work. So, daily activities are subject to their daily occupational and non-occupational energy expenditure<sup>1,2</sup>.

Energy requirements should be estimated based on energy expenditure rather than its intake. Errors and bias related to self-reported food records and conversion of actual energy production from uncooked to cooked food in a human body are often common in

diet prescriptions. Stored fat is usually used as ready-to-use energy in the body during less energy intake due to less food consumption or excess activities. However, such occurrences typically happen briefly among persons with or without diet. Some research shows that more energy intake than energy expenditure has a high chance of causing obesity and other metabolic disorders among sedentary women mainly<sup>2</sup>. According to the National Institute of Nutrition report, 2020, Estimated Average Requirement (EAR) denotes the intermediate need for energy, which is desirable, and safe allowances for Indian males and females with reference age (19-39 years) and weight 65kg and 55kg, respectively. In contrast, Recommended Dietary Intake (RDI) indicates the energy requirement applicable for India’s healthy and adequately nourished population<sup>3</sup>. As per the 2010 report, the body weight of men was 60kg<sup>4</sup>.

There is insufficient scientifically-proven data about the Physical Activity Ratio (PAR), whether it will be more for Body Mass Index (BMI)>25 and less for lighter

\*Author for correspondence

women (BMI<18). As per ICMR 2010 and 2020, all RDI and EAR are presented based on standard, i.e., reference weight. Simultaneously, Physical Activity Levels (PAL) may be variable as per the BMI of women with overweight or obese. Therefore, this study aimed to determine the relationship between estimated Daily Energy Expenditure (eDEE), BMI, and PAL. The eDEE is the actual need for energy out of TEE or Total Energy Expenditure, compiling the Resting Energy Expenditure or REE, Thermic Effect of Food or TEF, and Active Energy Expenditure that is AEE<sup>3,4</sup>. The ICMR-NIN 2020 report categorizes PAL values as sedentary type 1.4, moderate 1.8, and heavy 2.3, considered reference PAL values.

Our study was to estimate the calorie deficit, that is, how much to restrict (kcal) in overweight or obese Indian women visiting dietitians with such complaints along with the metabolic syndrome.

## 2. Materials and Methods

### 2.1 Study Design

A cross-sectional survey study recruited 112 sedentary urban women in West Bengal (Kolkata and adjacent districts) who visited the dietitian's clinic from 1<sup>st</sup> September to 30<sup>th</sup> December 2022 for being overweight and other health issues, Polycystic Ovarian Syndrome (PCOS) and Sub Clinical Hypothyroidism (SCH)<sup>5</sup>. As per samples, 2 participants were normal weight but suffering from other health issues. All participants also provided signed consent forms before joining the study. Altogether, there was no dropout and missing data due to the short-term (four-month) study.

### 2.2 Tools and Techniques

We used the advanced digital scale Dr. Trust Body Fat and Composition Scale 2.0 (Nureca Inc. USA; Model-509; 2-digit precision) to get BMI and estimated BMR instantly at the clinic. A three-day diet record (two working and one non-working day) and 24-hour diet recall were noted for each participant through an in-depth semi-structured interview at the first visit. From morning to night, daily activities, including Active Energy Expenditure (AEE) calculated and considered in the form of Physical Activity Ratio (PAR). BMI considered Asian cut-off values that are overweight >22.9. Estimated PAL values with a range of 1.29-1.64 by analyzing their whole-day activities and a

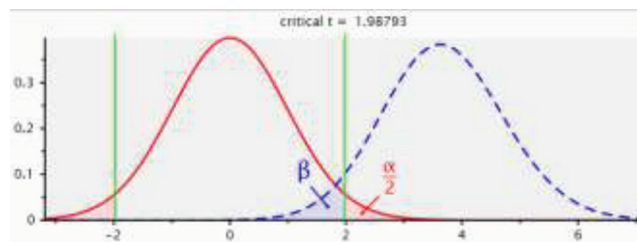


Figure 1. Alpha and Beta errors for sample size.

BMI range of 21.9 to 39.3 were noted<sup>6,7</sup>. A pre-tested semi-structured questionnaire was used for each participant to fill in all the information in the diet clinic<sup>8</sup>.

### 2.3 Estimation of Samples

We used G POWER: version-3.1.9.7 for sample size estimation based on effect size. The study showed small, medium, and significant correlations of .11, .19, and .29 in individual differences in psychology and health sciences research. The study effect size was found to be a predetermined 2-tailed T-test of 0.15 by the software, where the alpha error was 5% and power was 95% based on two predictors. This way, the estimated sample size found 89, where we considered 112 participants, more than the estimated size (critical t value 1.99)<sup>9,10</sup>.

### 2.4 Data Analysis

The total included variables were 11, with continuous BMI and PAL data. The rest were nominal data: BMR, TEE, REE, TEF, and AEE. Estimated DEE also functioned as continuous data in the study. Therefore, to determine whether there is a linear relationship between DEE as the dependent variable with BMI and PAL as the covariates, also called predictors.

### 2.5 Use of Software

Jamovi 2.3.21 was used to test the linear relationship by multiple regression model among DEE, BMI, and PAL, followed by the Correlation Matrix to find correlations among all study variables.

## 3. Results and Discussion

As per the study objective, we conducted Multiple Linear Regression (MLR) that follows the equation:  $Y = a + bX$ ;  $Y$  (dependent variable) =  $a$  (constant;  $y$ -intercept) +  $b$  (slope)  $X$  (predictors)<sup>11</sup>.

### 3.1 Multiple Regression Model

The study found that  $r$  as correlation coefficient = 0.839 ('good fit' as close to 1),  $R^2 = 0.704$  (reliable), and  $F$ -test = 130 ( $F > 2.5$ ). The model is fit due to the correctly considered two covariates, BMI and PAL (predictors). Therefore, the estimated DEE and two selected predictors have a highly linear relationship. Root Mean Squared Error (RMSE) and degree of freedom (df) are well-matched per the MLR model.

Table 1 shows  $p$ -value less than .001, which denotes that the model is highly statistically significant ( $p < 0.05$ ). Table 2 shows that the model coefficient estimated DEE is statistically significant due to  $p$ -values less than 0.001. Extensive sample size can say that a  $t$  value is essential if the absolute  $t$  value is  $\geq 1.96$ . At a 95% Confidence Interval, the study shows both the  $t$  values more than 1.96 (9.18 and 15.18). The test statistic is high enough; hence, the null hypothesis should be rejected due to data incompatibility, and the alternative hypothesis should be accepted.

**Table 1.** Model fit measure: overall model test

Activity	ICMR 2011	ICMR 2020
Sedentary	1900	1660
Moderate	2230	2130
Heavy	2850	2720

**Table 2.** Model Coefficients DEE (dependent variable) vs. BMI and PAL (independent variables)

Predictor	Estimate	SE	t	p
Intercept	91.4	95.56	0.956	0.341
BMI	11.8	1.29	9.177	<.001
PAL	834.1	54.94	15.18	<.001

### 3.2 Correlation Matrix

The correlation coefficient measures either a positive or negative relationship between two variables. A correlation matrix can be used to get a clear picture of the relationship between more than two variables in a tabular format. So, multiple regression shows the relationship as an equation, whereas correlation quantifies and signifies the strength of the linear relationship between a pair of variables.

In Table 3 correlation Matrix has been shown where all values are correlated as per the Pearson correlation

**Table 3.** Correlation matrix of all 9 variables to determine association and statistical significance

Model	R	R <sup>2</sup>	RMSE	F	df1	df2	p
1	0.839	0.704	48	130	2	109	<.001

**Table 4.** ICMR 2010 and 2020 reports on activity-wise energy requirements among Indian women<sup>3,4</sup>

Activity level	WHO/FAO/UNU	ICMR 2010	ICMR 2020
Sedentary	1.40-1.69	1.53	1.40
Moderate	1.70-1.99	1.80	1.80
Heavy	2.0-2.40*	2.30	2.30

coefficient ( $r$ ). In the matrix Table, we found that -0.263, -0.290, and 0.280 are statistically significant at  $p < .01$ , whereas the rest of all values in the matrix are highly statistically significant at  $p < 0.001$ . Therefore, the values in the correlation matrix are entirely highly correlated and statistically significant.

Please note: such PAL may be for a short time.

The Estimated Energy Requirement (EER) is the Total Energy Expenditure (TEE) for an Indian adult with reference weight and age, as discussed earlier. In our study, we explained women participants' daily energy expenditure and calculated PAL values based on their activities, as Tables 4 and 5 show. The estimated BMR, PAL values, and laboratory test reports were noted in the diet clinic on the first visit, with complaints of being overweight, having PCOS, and HT.

### 3.3 Factors Associated with BMR

Many studies pointed out that BMR is 70–80% of total daily energy use, and the Thermic Effect of Food (also called thermogenesis) is 5-10%. In some studies, TEF is also termed diet-induced energy expenditure. Active Energy means regular physical activity for at least 30 minutes that takes 20% part of TEE. Total lean mass (muscle mass) also influences BMR. So, any activity or supplement that reduces lean mass will reduce BMR<sup>12</sup>. As per reports of WHO/FAO, BMR is considered over-estimated. Hence 5% reduction started in 2010, and 10% for males and 9% for females' reduction has already been proposed in 2020 ICMR-NIN reports<sup>3,4</sup>. Currently, fad diets or crash diets are much popular. Crash dieting, intermittent fasting, and starving, which means eating too few kilocalories that influence the body to conserve energy by slowing metabolism<sup>2</sup>. In such cases, BMR can

**Table 5.** Differences in activity-wise PAL values among Indian women<sup>3,4</sup>

Variables	Correlation	BMI	PAL	BMR	TEE	REE	TEF	AEE	DEE	CD
Body Mass Index	Pearson's r	—								
	p-value	—								
Physical Activity Level	r	-0.263**	—							
	p	0.005	—							
Predicted BMR	r	0.777	-0.290**	—						
	p	<.001	0.002	—						
Estimated TEE	r	0.332	0.705	0.472	—					
	p	<.001	<.001	<.001	—					
Resting Energy Expenditure	r	0.332	0.705	0.472	1	—				
	p	<.001	<.001	<.001	<.001	—				
Thermic Effect of Food	r	0.331	0.705	0.473	1	1	—			
	p	<.001	<.001	<.001	<.001	<.001	<.001	—		
Active Energy Expenditure	r	-0.315	-0.430	-0.386	-0.669	-0.669	-0.668	—		
	p	<.001	<.001	<.001	<.001	<.001	<.001	<.001	—	
Estimated Daily Energy Expenditure	r	0.280**	0.689	0.423	0.954	0.954	0.954	-0.415	—	
	p	0.003	<.001	<.001	<.001	<.001	<.001	<.001	<.001	—
Calorie Deficit	r	0.352	0.600	0.462	0.887	0.887	0.886	-0.937	0.708	—
	p	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001

Note. r means Pearson's r; p means p-value; 2 values in the Table are showing \*p<.01, rest all values \*\*p < .001; All values are estimated

drop by up to 15 percent and may be reduced more if lean muscle tissue is lost or gradually lost.

### 3.4 Energy Segregation of TEE

Maintenance or Resting Energy Expenditure (REE), energy expenditure for Digesting Food Eaten (TEF), and Activity-Induced Energy Expenditure (AEE) make up Total Energy Expenditure (TEE). The effects of dietary and physical activity changes on energy expenditure are discussed, followed by a comparison of Total Energy Expenditure (TEE) to the three components that account for differences in subject characteristics such as body size and composition<sup>13</sup>.

### 3.5 REE and Other Factors

The Resting Energy Expenditure (REE) recorded within the first few minutes after waking up in the morning, and at least 12 hours after the last meal, is the gold standard for defining Basal Metabolic Rate (BMR). The Resting Energy Expenditure (REE) may be lower than the Basal

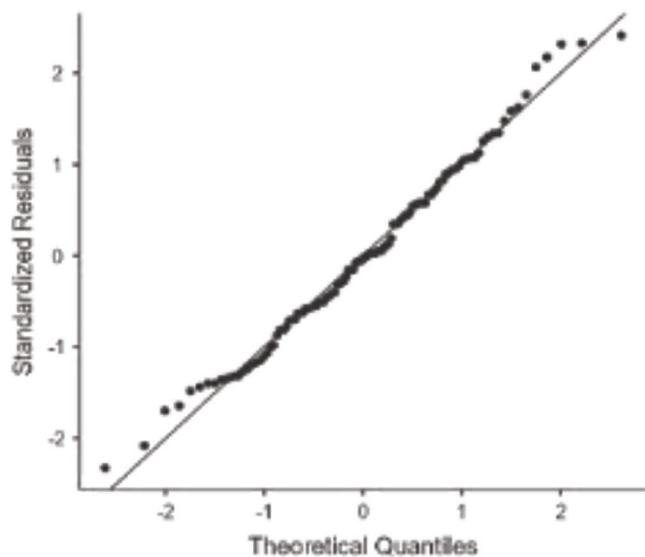
Metabolic Rate (BMR) in the case of fasting or calm sleep. In common parlance, the distinction between BMR and REE is negligible (less than 10%)<sup>13,14</sup>.

### 3.6 Calorie Restriction (CR)

The most potent non-pharmacological intervention to promote metabolic health is Calorie Restriction (CR). In addition to weight loss, calorie restriction has other benefits. Numerous studies have found that a CR causes a decrease in energy expenditure that exceeds the loss of metabolic mass or the sum of lean body mass and fat mass. CR measures how much less energy is consumed than is needed to maintain essential bodily functions over time<sup>15</sup>.

### 3.7 Calorie Deficit (CD)

There is no specific guidelines, equation, or theory in literature to calculate calorie (Kcal) to reduce or deficit if one is overweight or obese. There are suggestions to minimize the average 500 kcal (or the same amount kilojoules) in Western countries, but lack of research on



**Figure 2.** Residual vs. Quantile to assess distribution.

specific energy intake and expenditure population-wise. As per various Indian reports, the recommended energy intake and expenditure are often overestimated for Indian people than Western countries. This is due to climate, dietary habits, activities and exercise patterns, food selection, body composition, etc.

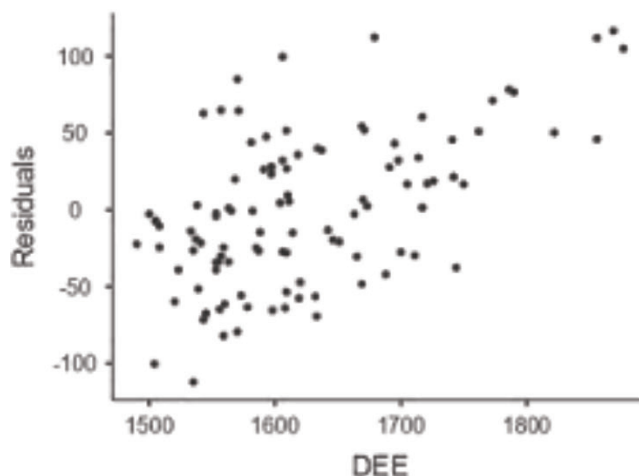
In this study, CD is the difference in estimated Total Energy Expenditure (TEE) and Daily Energy Expenditure (DEE) to determine the cutting value of daily energy (extra kcal) for an overweight or obese woman to reduce weight. DEE is the actual expenditure of REE, TEF, and AEE (nil or 5%) observed daily among the participating women. TEF is also termed diet-induced energy expenditure<sup>15</sup>, but we considered DEE an abbreviation for actual daily energy expenditure for an overweight woman. However, in the common term, TEE is the assessed value for daily energy expenditure, provided the person is normal in BMI as per the Asian cut-off value<sup>18</sup>.

Our study is based on the revised equation of Harris-Benedict, as mentioned herewith. The revised equation on BMR for women =  $447.6 + 3.1 \times (\text{length in cm}) + 9.2 \times (\text{weight in kilogram}) - 4.3 \times (\text{age})$ . The 95% confidence range is  $\pm 201 \text{ kcal/day}$  for women<sup>16-18</sup>.

So, as per the aim of our study, the formula is to find out the estimated Calories Deficit (CD)

$$[\text{BMR} \times \text{PAL}] = \text{TEE} [\text{REE} (70\%) + \text{TEF} (10\%) + \text{AEE} (0\% \text{ or } 5\%) = \text{DEE}]$$

Therefore,  $\text{TEE} - \text{DEE} = \text{CD} = \text{Recommended Calorie Deficit (Kcal)}$ .



**Figure 3.** Residual vs. DEE in the regression model.

Note: Usual calorie deficit for obesity and metabolic rate management is 15%-20%; all values are estimated.

## 4. Conclusions

Obesity among women is one of the significant lifestyle disorders globally. In such health issues, there is a need to cut extra calories (kilocalories) through proper diet, exercise, or both proportionately. There is no specific guidelines, equation, or theory in literature to calculate calorie to reduce if one is overweight or obese. Considering the importance of nearby calorie-cutting value before diet prescription, we conducted this short-term study. The study concludes that recommended Calorie Deficit (CD in kcal) can be the subtracted value of the estimated value of total energy expenditure and daily energy expenditure as actual calories spent by an obese woman per day.

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