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Original Article

Physiology Section

Measurement of Resting Energy Expenditure with Indirect Calorimetry and Predictive Equations in Healthy Young Adults: A Cross-sectional Study

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ABSTRACT

Introduction: Resting Energy Expenditure (REE) is the main determinant of energy requirements. An inaccurate estimation of REE can lead to the over or under-prediction of energy requirements. Indirect calorimetry is considered as the gold standard for the assessment of REE. The most of the predictive equations which are formed, are from the studies conducted on Caucasian people while on Asian population these studies are very limited.

Aim: To compare the REE measured by indirect calorimetry and predictive equation in healthy young adults.

Materials and Methods: A cross-sectional study was done on 100 healthy young adult participants from November 2018 to May 2019, of age group 18 to 25 years to measure REE using indirect calorimetry and predictive equations (Harris-Benedict's, Schofield, FAO/WHO/UNU and Mifflin-St. Jeor equations). Statistical analysis was carried out using SPSS version 16.0. Unpaired student t-test for comparison of data and Bland Altman test to check for validity of predictive equations were applied.

Results: The mean value of REE using Indirect calorimetry was 1994.20±577.33 and that of using four Harris-Benedict's, Schofield, FAO/WHO/UNU and Mifflin-St.Jeor equations were 1638.15±335.64 kcal/day, 1636.21±359.85 kcal/day, 1636.93±367.59 kcal/day and 1582.41±251.29 kcal/day, respectively. Thus, the highest mean difference between values of REE obtained using predictive equation and indirect calorimetry was 411.79±326.04 kcal/day with respect to Mifflin-St.Jeorand's and the lowest mean difference was 356.05±241.69 kcal/day with respect to Herris Benedict's equation.

Conclusion: Predictive equations underestimated the REE of young adults when compared with that measured by indirect calorimetry.

Keywords: Herris-benedict, Mifflim-jeor, Resting metabolic rate, Schofield

INTRODUCTION

Human body requires some amount of energy to be burned regularly in 24 hours to perform various activities, total amount of this energy is referred as Total Energy Expenditure (TEE). TEE is actually composed of 3 main components: Thermic Effect of Food (TEF), Activity Energy Expenditure (AEE) and REE [1]. TEF is the increase in energy expenditure, associated with the ingestion of food and it accounts for approximately 10% of the total daily energy expenditure [2]. Energy expenditure during physical activity is also called as AEE. It is the most variable component of total daily energy expenditure and accounts for energy consumed in muscular work during spontaneous and voluntary exercise [3].

REE is the largest portion of TEE. It is required to maintain the basic metabolic activities of body including maintenance of its temperature and keeping the functioning of vital organs such as the brain, the kidneys, the heart, and the lungs. Thus, REE can be defined as the energy expended by a fasting person at rest, in a thermo-neutral environment. Measurement for REE should be performed in the postprandial state, at least six hours after consumption of any calories or performing any rigorous activity. Subjects should be fully rested while supine for 60 minutes prior to the measurement, so that it does not coincide with TEF or AEE [1].

Inter-individual variability is accountable while measuring REE, because it is affected by factors like age, gender, body size, body composition, ethnicity, physical activity level and a range of genetic and environmental influences [4-8]. Ethnic differences are known to account for creating variation in REE. Previous studies shows that REE is lower in African American than in white normal-weight women and obese children, this may be related to difference in trunk lean body mass and entire body composition of people from different ethnicity [9,10].

REE is the main determinant of energy requirements; An inaccurate estimation of REE can lead to the over or under-prediction of energy requirements. Indirect calorimetry is considered as the gold standard for the assessment of REE. REE can also be assessed with the help of predictive equations [11]. It is known that more than 100 predictive equations have been developed [12-14] in order to circumvent this method and decrease the inconsistency between measurements. These equations are based upon regressive analysis of body weight, height, sex, and age, or analysis of some independent variables, such as fat free mass, fat mass, body surface area [15].

The most of the predictive equations formed are from the studies conducted on Caucasian people [12,16-18] while on Asian population these studies are very limited [19-21]. Hence, the present study was designed to compare the REE measured by indirect calorimetry and some most of the widely used predictive equations such as Herris-Benedict's, Schofield's, WHO/FAO/UNU and Mifflin-Jeor's equations.

MATERIALS AND METHODS

The present cross-sectional study was conducted in the Department of Physiology, RUHS College of Medical Sciences, Jaipur, Rajasthan, after approval by RUHS Ethical Committee (EC/P-35/2018). Study was carried out from November 2018 to May 2019. All participants were provided an informed consent after adequate explanation of the procedure to be followed during the study.

Inclusion criteria: A total of 100 apparently healthy young adult subjects with 32 females and 68 males, aged between 18-25 years were recruited randomly for the study after obtaining their consent.

Exclusion criteria: Subjects with history of hospitalisation in the

last 3 months, Smokers and alcoholic, Individuals suffering from Hypertension, Diabetes and other metabolic disorders, Cardiac, Respiratory disorder such as asthma, COPD, pneumothorax, respiratory tract infection and musculoskeletal disorders were excluded.

Experimental Protocol

Basic demographic parameters including height, weight, gender and age were taken from all participants, which are of prime requirement for measuring REE using various predictive equations.

Predictive equations used in the study are similar for either sex and is as follows:

Harris-Benedict equation [12]

66.437 + (13.752 x weight) + (5.03 × height)-(6.755 × age)

Schofield equation [16]

For age group 18-29 years: 15.057 × (weight)+ 692.2

WHO/FAO/UNU equation [17]

For age group 18-30 years: 15.4 × weight-27 × (height/100) + 717

Mifflin-St Jeor equation [18]

9.99 × weight + 6.25 × height-4.92 × age + 5

All the equations mentioned above are similar for men as well as for women.

It was followed by performing indirect calorimetry on all the participants with the help of in-build indirect calorimeter in AD instruments Gas Analyser (LabChart v81.11), which calculates REE using weir equation:

REE = 3.9 (VO_2) + 1.1 (VCO_2) × 1.44

All the participants were asked to fast overnight and not to exercise for 48 hours prior to the measurement. Participants, after their arrival in the laboratory, were asked to rest for about 30 minutes, and then were made to wear a mask through which only they were allowed to breathe in and out, while lying on the couch comfortably. Mask was connected to the gas analyser with the help of a connecting pipe via gas mixing chamber. Measurement was taken for 40 minutes and steady state data was averaged and used for the purpose of measurement of REE. Data from first 5 minutes was discarded as it is the time supposed to be utilised by the participants to adjust themselves comfortably on the couch. The calorimeter measures the amount of O_2 consumed and the amount of CO_2 produced while at rest by comparing the concentrations of O_2 and CO_2 in the air inspired by the participant with the concentration in the air exhaled by the participant.

Indirect calorimetry is the Gold Standard method of REE measurement, thus the results obtained from predictive equations were compared with results of indirect calorimetry and checked whether equation predicts the REE correctly or not. If the predictive REE results to be higher than measured REE (by indirect calorimetry) then it is called overestimated values. Similarly, if predictive REE is lesser then measured REE then it is called underestimated values.

STATISTICAL ANALYSIS

The results of study are presented as mean±SD. Data were compared between genders using unpaired student t-test. To check the validity of predictive equations Bland Altman test was applied. Analysis was carried out using SPSS version 16.0 (Chicago, Inc., USA), significance level for p-value calculated at p≤0.05.

RESULTS

The mean age, height, weight and BMI of all participants were 19.97±2.05 years, 167.92±8.61 cm, 60.68±11.55 kg and 21.53±3.83 kg/m^2, respectively [Table/Fig-1].

Male participants of study were having significantly higher REE than female participants [Table/Fig-2].

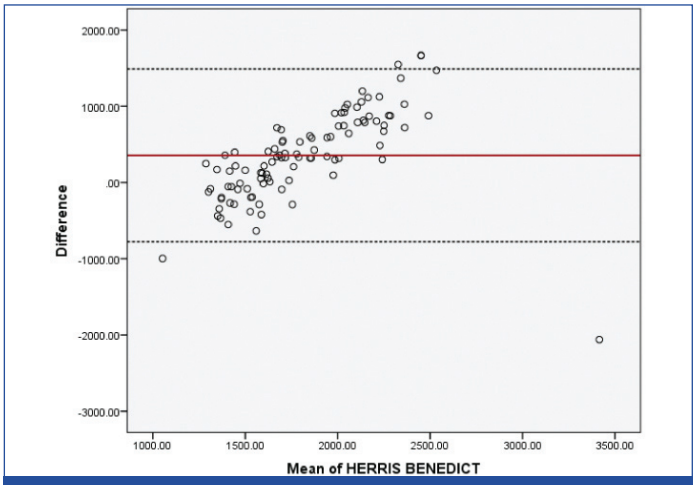
Parameter	Mean±SD (100)	Males (68)	Females (32)	p-value
Age (years)	19.97±2.05	20.07±2.01	19.75±2.12	0.29
Height (cm)	167.92±8.61	172.04±6.25	159.54±6.39	**0.001**
Weight (kg)	60.68±11.55	66.97±27.42	53.96±9.93	**0.001**
BMI (kg/m^2)	21.53±3.83	21.61±3.8	21.36±3.81	0.3

[Table/Fig-1]: Demographic data of study participants.
p-values at 0.001 as significant

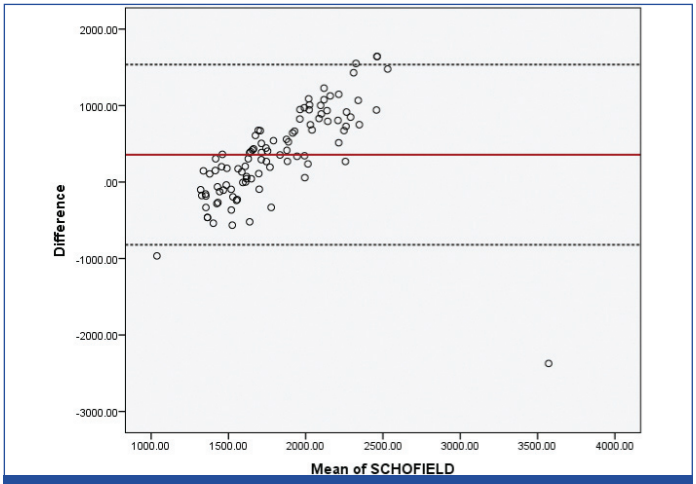
Methods	REE (Mean±SD) [N=100]	REE (Mean±SD) males [N=68]	REE (Mean±SD) females [N=32]	p-value
Indirect Calorimetry (Kcal/Day)	1994.20±577.33	2145.61±611.37	1686.78±338.78	**<0.001**
Herris benedict (Kcal/Day)	1638.15±335.64	1717.19±372.05	1477.67±152.92	**<0.001**
Schofield (Kcal/Day)	1636.21±359.85	1700.70±412.98	1505.26±149.85	**<0.001**
WHO/FAO/UNU (Kcal/Day)	1636.93±367.59	1701.87±427.48	1505.05±152.01	**<0.001**
Mifflin-St.Jeor (Kcal/Day)	1582.41±251.29	1650.53±270,36	1444.10±123.13	**<0.001**

[Table/Fig-2]: REE measured by indirect calorimetry and predictive equation for males and females.
Unpaired student t-test. p-value <0.001 is highly significant

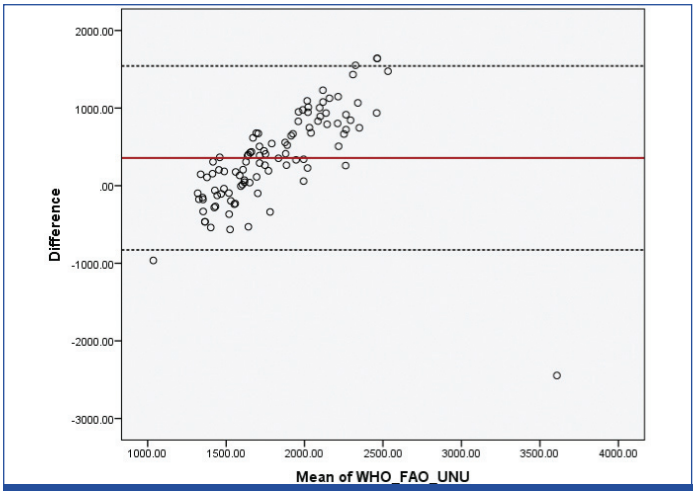
Plots explain that difference between REE measured using indirect calorimetry and predicted equation does not coincide and indicates that the difference between the mean values of REE measured by using indirect calorimetry and each predictive equation was highly significant [Table/Fig-3a-d].



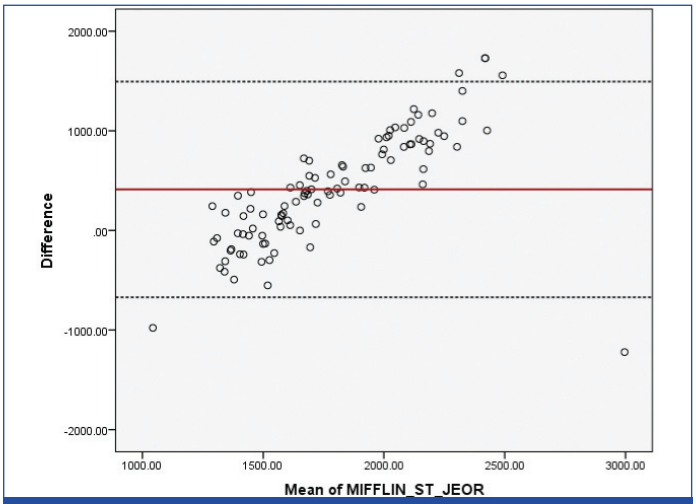
[Table/Fig-3a]: Bland Altman plot comparing REE obtained by Indirect Calorimetry and Herris benedict's equation.



[Table/Fig-3b]: Bland Altman plot comparing REE obtained by Indirect Calorimetry and Schofield's equation.



[Table/Fig-3c]: Bland Altman plot comparing REE obtained by Indirect Calorimetry and WHO_FAO_UNU equation.



[Table/Fig-3d]: Bland Altman plot comparing REE obtained by Indirect Calorimetry and Mifflin Jeor's equation.

According to the results obtained all four predictive equations underestimated the REE of young adults when compared with the REE measured by indirect calorimetry. The highest mean difference between values of REE obtained using predictive equation and indirect calorimetry was 411.79±326.04 kcal/day w.r.t. Mifflin-St. Jeor (1994.20±577.33-1582.41±251.29) and the lowest mean difference was 356.05±241.69 kcal/day wrt Herris Benedict (1994.20±577.33-1638.15±335.64) [Table/Fig-3a-d,4].

Methods	REE (Mean±SD) kcal/day	p-value
Indirect calorimetry	1994.20±577.33	
Herris benedict	1638.15±335.64	**0.001**
Schofield	1636.21±359.85	**0.001**
WHO/FAO/UNU	1636.93±367.59	**0.001**
Mifflin-St.Jeor	1582.41±251.29	**0.001**

[Table/Fig-4]: Comparison of the REE measured by indirect calorimetry and predictive equations using bland altman analysis.

DISCUSSION

In the present study, predictive equations used were Harris-Benedict's equation, Schofield's equation, Mifflin-St.Jeor's equation, WHO/FAO/UNU equation and the results acquired were compared with that of indirect calorimetry. The mean value of REE measured by indirect calorimetry was significantly higher than the predicted REE values obtained using the predictive equations mentioned above. In the present study, Herris Benedict's equation underestimated the values of REE which is congruent with a previous study performed by Al Domi H et al., on obese and non-obese healthy young adults [22]. Prado de OE and Lera OF, conducted a study comparing the values of REE predicted by Mifflin-Jeor's and WHO/FAO/UNU equations with indirect calorimetry and reported diminished values of REE by these equations, which supports the results of present study [23]. Another study conducted by Joseph M et al., in southern region of India provided the lower values of REE when predicted by using WHO/FAO/UNU, Mifflin-Jeor's and Herris Benedict's equation and compared with that derived from indirect calorimetry [20].

Similarly, a study conducted by Dasgupta R et al., in normoglycemic and diabetic Asian subjects also reported the underestimated values of REE using Schofield and other equations which again matched with the results of present study [24].

When we compared the indirect calorimetry derived REE with predicted REE, none of the four equations in this study were found to be accurate as they all underestimated the value of REE. Joseph M et al., also concluded that these predictive equations were inaccurate for Asian population [20].

Thus, the present study suggests that these equations are not suitable to use and predict REE in Indian population and there is still need of some new equations which can predict the actual values of REE for ethnicity of Indian population. The present study strongly suggests the use of indirect calorimetry whenever REE is in need to be measured.

Limitation(s)

Sample size in the study was small and included only healthy young adult population.

CONCLUSION(S)

It was observed that the predictive equations which are available in literature were used, they underestimated the REE. It is therefore important that whenever correct and precise measurements are required, one should use the indirect calorimetry method. For external validity of results further study on a larger population including a wider age group of individuals is suggested.

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