COMPARISON OF HARRIS BENEDICT AND MIFFLIN-ST JEOR EQUATIONS WITH INDIRECT CALORIMETRY IN EVALUATING RESTING ENERGY EXPENDITURE

BAHAREH AMIRKALALI, SAEED HOSSEINI, RAMIN HESHMAT, BAGHER LARIJANI

ABSTRACT

BACKGROUND: ***An understanding of energy expenditure in hospitalized patients is necessary to determine optimal energy supply. The metabolic rate can be measured or estimated by equations, but estimation is by far the most common method. AIM: This study tests the degree of agreement between measured resting energy expenditure by indirect calorimetry and predicted resting energy expenditure by Harris Benedict and Mifflin-St Jeor equations. Patients were categorized according to sex and diagnosis. SETTINGS AND DESIGN: Cross-sectional study. MATERIALS AND METHODS: In 60 randomly selected patients, aged between 18 and 83 years, resting energy expenditure (REE) was measured by indirect calorimetry and compared with the predicted equations of Harris Benedict and Mifflin-St Jeor. STATISTICAL ANALYSIS: Statistical analysis was performed by using the method of Bland-Altman, one sample t-test and Pearson's correlation. RESULTS: There was no statistically significant difference between measured and predicted resting energy expenditure by both equations, in all cases as a whole and each group. The only statistically significant difference was seen between measured resting energy expenditure and its predicted equivalent by Mifflin-St equation when patients were categorized according to their sex. Limits of agreements were wide for both equations in all cases and each category so clinical significance was considerable. CONCLUSIONS: At a group level Harris-Benedict equation is suitable for predicting REE but at an individual level, both equations have wide limits of agreement and clinically important differences in REE would be obtained.***

Key words: Calorimetry, Harris Benedict, Mifflin-St Jeor, resting energy expenditure

The Endocrinology and Metabolism Research Centre (EMRC) of the Tehran University of Medical Sciences (TUMS), Shariati Hospital, North Kargar St., Tehran 1411713137 Iran

Correspondence:
Dr. Saeed Hosseini
Nutrition and Biochemistry Department,
Tehran University of Medical Sciences,
The Endocrinology and Metabolism Research Centre (EMRC) of the Tehran University of Medical Sciences (TUMS),
Shariati Hospital, North Kargar St.,
Tehran 1411713137 Iran.
E-mail: saeedhmdphd@hotmail.com

INTRODUCTION

Proper nutritional support as part of daily therapeutic interventions has been shown to improve morbidity and mortality.[1] Delayed or inadequate feeding may lead to impaired wound healing and immune dysfunction.[2,3] On the other hand overfeeding may result in other significant complications such as hepatic

dysfunction, hyperglycemia and increased carbon dioxide production.[1,4] Both under- and overfeeding may prolong hospitalization and increase morbidity and mortality.

So accurately assessing energy needs of each patient is important in effective nutrition support.

Many disease processes result in elevated caloric requirements whereas some clinical procedures and medications may diminish the metabolic response. Applying equations that were originally developed for healthy non-hospitalized individuals to predict the energy requirements of hospitalized patients may lead to provision of inappropriate nutritional support. In the clinical setting, however, measurement of energy expenditure is time consuming and expensive. As such, prediction equations using easily measurable variables are commonly used to predict resting energy expenditure which account for approximately 60-80% of total energy expenditure.[5-7]

Studies comparing mean measured resting energy expenditure (MREE) by indirect calorimetry and predicted resting energy expenditure (PREE) by Harris benedict and Mifflin-St Jeor equations have shown inconsistent results.[8-11] Most of these studies have compared MREE and PREE at the group level, whereas individual predictive accuracy is important in the clinical setting. The method described by Bland and Altman is the appropriate statistical analysis for assessing agreement between two measurement methods.[12]

Harris benedict and Mifflin-St Jeor equations are commonly used to predict resting energy expenditure in hospitalized patients. Therefore the purpose of this study was to assess the degree of agreement between measured resting energy expenditure (MREE) by indirect calorimetry and predicted resting energy expenditure (PREE) by Harris Benedict and Mifflin-St Jeor equations.

MATERIALS AND METHODS

In this cross-sectional study, sixty patients, 18-83 year old, were randomly selected from different wards of Shariati Hospital (Tehran, Iran) for two months. Patients were randomly selected from admission records. Admission diagnosis varied, general surgery (N=6, all with multiple trauma), cancer [N=25, Blood cell malignancies 9(36%) (Number of patients (percentile), Gastrointestinal malignancies 9 (36%), Brain Tumors 5 (20%), other malignancies 2 (8%)] and general internal medicine [N=29, Gastrointestinal disorders 10 (35%), Uro-renal disorders 6 (21%), Pulmonary disorders 4 (14%), Neurological disorders 3 (10%) and other disorders 6 (20%)].

Subjects were excluded for one of the following reasons:

- Severe behavioral or cognitive disorders,
- Having mechanical ventilation
- Supplemental oxygen or chest tubes

Measurements were taken on all subjects by trained and certified nutritionists using a standardized protocol. Body weight to the nearest 0.5 kg was determined before REE measurement on a Seca 750 Dial Home Mechanical Scale with the subject in hospital clothes and without shoes. Height was measured with Seca 200 Girth Measuring Tape according to established protocol (without shoes; heels together; subject's heels, buttocks, shoulders, and head touching the vertical wall surface; and with line of sight aligned horizontally). REE was measured using fitmate calorimetry (Cosmed Company, Via dei Piani di Monte Savello 37, Pavona di Albano - Rome I - 00040 ITALY). The FitMate is new, small (20 x 24 cm) metabolic analyzer with a mask covering nose and mouth of the person, designed for measurement of oxygen consumption and energy expenditure during rest and exercise. It uses a turbine flowmeter for measuring ventilation, a galvanic fuel cell oxygen sensor for analyzing the fraction of oxygen in expired gases, and incorporates a patent pending innovative sampling technology that allows the FitMate to retain the performance of a metabolic cart with a standard mixing chamber. RMR is calculated from oxygen consumption, a fixed respiratory quotient (RQ) of 0.85, and estimated grams of urinary nitrogen using a modified Weir equation.

Weir equation: REE = [o_2 consumed (litre)× 3.941+ produced co_2 (litre) ×1.11] ×1440 min/d

REE was measured after an overnight fast or continuous parenteral or enteral feeding. It is not necessary to suspend continuous parenteral or enteral feeding for in these two methods thermic effect is minimal and no additional calories are required for thermogenesis.[13] Subjects were instructed to fast and abstain from physical activity for 12h before the test and to refrain from smoking ≥ 1h before testing but for 12h if possible so they were in resting and post-absorptive condition. Patients were asked to rest in a supine position on a mattress for 15 min and then measurement was performed for 7 min. The first 2 minutes were omitted and the last 5 minutes were used to calculate REE.

PREE was calculated using Mifflin-St Jeor and Harris Benedict Equations as follow:

Harris Benedict equations

Male: RMR = 66.47 + 13.75 ×W + 5.0 ×H -6.75 × A

Females: RMR= 665.09 + 9.56 × W + 1.84 × H-4.67 × A

Mifflin-St Jeor equations

Males: RMR = 10×W + 6.25×H -5 × A + 5

Females: RMR =10×W + 6.25×H -5 × A -161

Where REE stands for Resting Energy Expenditure (kilocalorie per day), W for weight (kilogram), H for height (centimeter) and A for age (year).

Data were analyzed using SPSS version 11.5. Mean standard deviation (SD) and frequencies were the descriptive statistics used to present patients' characteristics. Patients were categorized into three diagnosis (general surgery, cancer and general internal medicine) and two sex groups.

One sample t-test was used to assess differences between MREE and PREE by each equation. We used Bland and Altman approach to assess the agreement between MREE and PREE. This analysis allowed for the calculation of bias (mean of the individual differences) and the limits of agreement (± 2 SD from the mean bias). Correlation analysis (Pearson's test) was used to examine the association between the mean of the measured and predicted REE, and the differences between the two

methods. A *P*-value less than 0.05 was defined as statistically significant. The interpretation of the differences was not based solely on statistical testing but also on clinically important differences in energy expenditure which was defined a priori to be greater than 96 kcal/day for this sample of patients.[14]

This study received ethics approval from the human research ethics committee of Tehran University of medical science.

RESULTS

There were 60 patients in this study, 33 men (55%) and 27 women (45%). Mean age of participants was 44.38 ± 19.03 years (range: 18-83). Mean MREE was 1311.66 ± 373.98 kcal/d. Mean PREE from Harris Benedict and Mifflin-St Jeor equations were 1339.36 ± 223.48 kcal/d and 1303.11 ± 230.94 kcal/d respectively.

Table 1 shows the result of one sample t-test, the bias [mean difference between PREE and MREE, (PREE-MREE)] and limits of agreemen: (±2 standard deviations of the bias) for the prediction of REE from Harris Benedict equation relative to the MREE in all cases an in each diagnosis and sex category. Table 2 shows the same analysis for Mifflin-st Jeor equation.

One sample t-test showed no significant differences between PREE from equations (Harris Benedict and Mifflin-st Jeor) and MREE in all cases as a whole. The result was the same when patients were categorized according to their diagnosis. When this analysis was performed for each sex separately there was no significant difference between PREE from Harris Benedict equation and MREE in both sexes but the difference was significant between MREE and PREE from Mifflin-St Jeor equations in both males and females. Mifflin-St

Table 1: Comparison between measured and predicted resting energy expenditure by Harris-Benedict equation

		N	*Bias*	*Limit of agreement*	*One sample t-test*			
			(Mean differences ±SD kcal/d)	*(± 2 SD; kcal/d)*	*t value*	*df**	*95% Confidence interval*	*P-value*
All cases	60	28 ± 371	-714 to 770		0.6	59	-123_68	0.6
Diagnosis	General surgery	6	-128 ± 188.5	-505 to 249	-1.6	5	-325_70	0.16
	Cancer	25	-24.6 ± 424.5	-874 to 824.4	-0.3	24	-200_151	0.8
	Internal medicine	29	-10 ± 356	- 722 to 702	-0.14	28	-145_126	0.9
Sex	Male	33	-136 ± 407	-950 to 678	-1.9	32	-280_8	0.06
	Female	27	105 ± 275	445 to 655	1.9	26	-4_214	0.058

*Degree of freedom

Table 2: Comparison between measured and predicted resting energy expenditure by Mifflin-St Jeor equation

		N	*Bias*	*Limit of agreement*	*One sample t-test*			
			(Mean differences ±SD kcal/d)	*(± 2 SD; kcal/d)*	*t value*	*df†*	*95% Confidence interval*	*P-value*
All cases		60	- 8.5 ± 392	-793 to 776	-0.17	59	-93_110	0.8
Diagnosis	General Surgery	6	-88 ± 183	- 454 to 278	-1.1	5	-298_104	0.3
	Cancer	25	11 ± 441	-871 to 893	0.12	24	-171_193	0.9
	Internal Medicine	29	27 ± 386	-745 to 799	0.4	28	-120_173	0.7
Sex	Male	33	-156 ±398	952 to 952	-2.2	32		0.03*
	Female	27	210 ± 277	-344 to 764	4	26	100_319	0.001*

*Statistically significant, †Degree of freedom

Jeor equation underestimated REE in females but overestimated REE in males.

Bland-Altman method showed that when analyzed in all cases, both equations had wide limit of agreements (less or more than 96 kcal/d). This result was the same in all cases and in each diagnosis and sex category. The bias for all prediction methods was not consistent across the range of measurements of REE as the mean of MREE and PREE was significantly correlated with the difference between MREE and PREE for both Harris Benedict and Mifflin-St Jeor equations [Table 3 and Figures 1-2]. The result was the same when analysis was performed in each sex and diagnosis group separately except for general surgery group where there was no significant correlation between mean of MREE and PREE and their difference probably as a result of low number of cases in this group.

As a whole there was no statistically significant difference between MREE and PREE for both equations in all cases and in each group. The only statistically significant difference was for Mifflin-St Jeor equation in each sex group but clinical significant difference (less or more than 96 kcal/d) was seen in all cases all diagnosis and sex groups.

DISCUSSION

The aim of this study was to compare the agreement between PREE from Harris Benedict and Mifflin-St Jeor equations to MREE in a group of hospitalized patients. For good agreement, it is expected that bias will be close to zero, the limits of agreement are narrow enough to be clinically acceptable

Table 3: Correlations between the mean of MREE and PREE and their differences for Harris Benedict and Mifflin-St Jeor equations

Groups		*N*	*Harris Benedict Equations, r (P-value)*	*Mifflin-St Jeor equation, r (P-value)*
All cases		60	0.5 (< 0.001)*	0.4 (< 0.001)*
Diagnosis	General Surgery	6	0.6 (0.2)	0.7 (0.14)
	Cancer	25	0.5 (0.016)*	0.44 (0.03)*
	Internal Medicine	29	0.5 (0.003)*	0.5 (0.007)*
Sex	Male	33	0.5 (0.004)*	0.7 (< 0.001)*
	Female	27	0.7 (< 0.001)*	0.6 (0.001)*

*Statistically significant

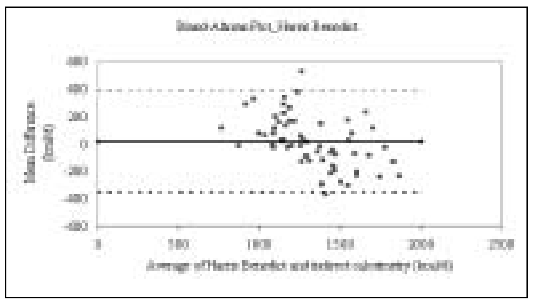

Figure 1: Differences between MREE by indirect calorimetry and PREE derived from Harris-Benedict equation vs the mean of MREE and Harris-Benedict PREE

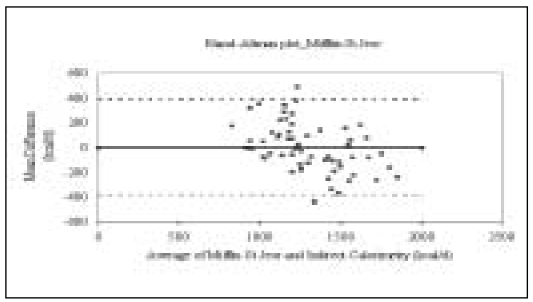

Figure 2: Differences between MREE by indirect calorimetry and PREE derived from Mifflin-St Jeor equation vs the mean of MREE and Mifflin-St Jeor PREE

and that there is no clear evidence of a relationship between difference and mean of measured and predicted REE. Based on these assumptions our results show that as there are no statistically significant differences between PREEs from Harris Benedict equations and MREE by indirect calorimetry, in all cases as a whole and all diagnosis and sex categories, it can be used to predict REE at a group level but because of statistically significant differences between PREEs from Mifflin-St Jeor equation and MREE in each sex group it can not be safely used at a group level. Wide limits of agreement of both equations show that none of them can be used interchangeably with indirect calorimetry for an individual and there are clinically important differences.

Our results are in agreement with other studies in this field.[1,8,10] Boullata *et al*, in 2007 compared predictive equations of REE and indirect calorimetry in hospitalized patients and found that even the most accurate equation (the Harris-Benedict 1.1) was inaccurate in 39% of patients and had an unacceptably high error.[8] A research performed by Dickerson *et al*, on thermally-injured patients in 2002 showed that these patients are variably hypermetabolic and energy expenditure can not be precisely predicted.[1] In 1984 Dempsey *et al*, declared that the majority of gastro intestinal cancer patients have abnormal REE which is unpredictable and not uniformly hypermetabolic. The determinants of these abnormalities do not appear to be age, sex body size, nutritional status or tumor burden.[10]

Such gross over- or underestimation of energy requirements could lead to negative complications associated with over and underfeeding.[15] On the other hand a wide range of metabolism from hypo metabolic to hyper metabolic has been observed in hospitalized patients.[16-19]

The finding that these equations fail to accurately predict REE is not unexpected. The primary reason is that these predicted equations use weight as a primary variable, which is easy to measure but may not be the most suitable variable for estimating REE especially in hypo- or hyper metabolic states.

In clinical practice, measurement of energy expenditure is time-consuming and expensive so in spite of the limitations of prediction equations for use in individuals, clinicians require an estimate of REE. Harris Benedict and Mifflin-St Jeor equations are commonly used to predict resting energy expenditure in hospitalized patients. As the limits of agreement for both equations are wide, clinicians need to be aware of the limitations of the use of REE prediction equations for estimating individual REE in hospitalized patients. Monitoring of patients´ outcomes is the most effective method of determining whether patients are receiving adequate nutrition support. In a review article by Frankenfield *et al*, the expert panel advised clinical judgment regarding when to accept estimated RMR using predictive equations in any given individual. They concluded that noteworthy errors and limitations exist when it is applied to individuals and possibly when it is generalized to certain age and ethnic groups.[20]

It can not be assumed that REE is a physical measure regardless of genetics or body composition. This study did not include an evaluation of body composition, nor did it characterize the subject sample by internal diseases or ethnicity; therefore, well-controlled studies of REE in various ethnic groups in Iran considering these factors are needed in planning for nutritional care of these individuals. Furthermore, studies comparing measured and predicted REE taking into account various clinical factors, such as compliance with medical nutrition therapy, weight change, blood glucose control and requirements for medications would be useful for improving clinical nutrition care.

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