Original Article

Validity of predictive equations for resting energy expenditure among Iranian women

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Objectives: To determine the resting metabolic rate (RMR) in a sample of Iranian women, and to evaluate the validity of predictive equations for estimating RMR in normal and obese subjects. Methods: This cross-sectional study was conducted on a total of 187 healthy women aged 18-45 years. Anthropometric data were collected and subjects' RMR was measured by indirect calorimetry for 15 minutes following an overnight fast. RMR was also predicted using various types of formulas based on subjects' height, age, weight or fat-free mass. Body composition was estimated by bioelectric impedance analysis (BIA). Results: Measured RMR (mean ± SD) was found to be 1473 ± 296 kcal/day. The abbreviation formula overestimated RMR, while other formulas underestimated it. Harris-Benedict formula was valid among all BMI categories (normal weight, overweight, obese and morbidly obese). Two Schofield formulas were valid in normal weight, overweight and morbidly obese subjects; and Cunningham formula was valid only among overweight and obese women. Overweight and obese Iranian women had higher RMR in comparison with normal weight subjects ($p<0.01$); although after age and weight adjustment, the differences were not significant in any of the BMI categories. Conclusions: The Harris-Benedict for mula provides a valid estimation of RMR at the group level in a range of normal-weight to morbidly obese Iranians. However, at the individual level, errors might be so high that using a measured value has to be preferred over an estimated value.

Key Words: resting metabolic rate, predictive equations, validity, women, energy metabolism

INTRODUCTION

Prevalence of obesity and non-communicable chronic diseases such as type 2 diabetes, hypertension and coronary heart disease is increasing worldwide, especially in developing countries.[1] Following a healthy diet and regular physical activity has been shown to be an appropriate solution for the prevention and control of these diseases.[2] In this regard, understanding the energy expenditure of individuals or different populations is noteworthy, since it is one of the main determinants of food and energy requirements.[2]

Resting metabolic rate (RMR) is the major component of energy expenditure which is measured in resting state and is defined as the energy needed for maintenance of vital organ functions.[3] For the majority of people, RMR constitutes almost 60-70% of total energy expenditure[4] and hence is used for estimation of energy requirement of populations.[5] Although RMR can be measured by different methods (face mask, hood, nose clip, and whole-body human calorimeter),[6-8] the complexity of these tools, the expense of calorimeters, the time needed to accomplish a measurement and lack of experienced staffs to utilize them limit their application in clinical practice.[9] Therefore, various studies have been performed in order to obtain some standards for calculating RMR.[10] Multiple formulas have been proposed for RMR estimation, which are currently used in the evaluation of individuals' energy requirements in clinical assessments.[11] Equations for predicting RMR are based upon body weight, height, sex, age and fat-free mass (FFM) and it is claimed that, these formulas estimate metabolic rate in obese and underweight individuals inaccurately, and lead to major errors in energy requirement estimation of these populations.[2,11] Harris-Benedict and Schofield formulas have been previously shown to predict a valid estimate of RMR in

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normal and overweight individuals.[12] However, Harris-Benedict formula has shown 5-15% error in the estimation of RMR in very young and old subjects;[10] the Schofield formula, on the other hand, is based on Food and Agriculture Organization (FAO)/World Health Organization (WHO) guidelines and its validity has been assessed with different results in different populations.[2,11] These discrepancies could be explained by the fact that according to statistical laws, predictive regression equations work the best in groups of people and hence when regression equations are applied to an individual (as in clinical and research usage of RMR), significant errors might occur.[10,13] Furthermore, the probability of clinically important errors increases if the individuals' characteristics (age, sex, body mass, body composition and ethnicity) differ significantly from those of the group of people from whom the equation was originally developed.

Different formulas are used for estimating energy requirements in Iranian health clinics but to our knowledge, no previous study has evaluated the validity of these equations among Iranian population. Given the fact that predictive equations for RMR based on body composition are generally population-specific, evaluating the validity of these formulas in Iranian population seems necessary. Three objectives were followed in the present research: 1) measurement of resting metabolic rate in adult Tehrani women using indirect calorimetery, 2) evaluating formulas that are usually used for estimating RMR and comparing their validity with each other, and 3) evaluating and comparing the bias of RMR calculated by different formulas in subjects with different body mass index values (normal, overweight, obese and morbidly obese).

MATERIALS AND METHODS

Study population

This cross-sectional study was conducted on a representative sample of Tehrani women aged 18–45 years. By stratified random sampling, 232 women were selected from 20 municipal regions in Tehran. In each municipal region, some women were selected randomly from the data registry with respect to the population of that district. Among the 232 selected women who were invited to participate in the current study, 210 women gave written consent (response rate: 90.5%). In the morning of the test day, subjects were transferred to the "National Nutrition and Food Technology Research Institute" of Shahid Beheshti University of Medical Sciences. Subjects who had any chronic diseases or were taking any medications known to affect RMR (e.g. diuretics, corticosteroids, thyroid dugs) were excluded from the present study (n=23). None of the subjects were receiving or had received dietary counseling from a physician or dietitian and none had a history of weight change during the past two months. The protocols and procedures of the present study were approved by the ethics committee of Shahid Beheshti University of Medical Sciences and participants' anonymity was preserved.

Measurements

Anthropometric

Trained certified dietitians conducted all anthropometric and dietary intake assessments. Body weight was measured with subjects minimally clothed without shoes and was recorded to the nearest 100 gram using digital scales (Soehnle, Germany). Height was measured using a non-stretch tape meter fixed to a wall while subjects were standing without shoes with shoulders in a normal position and it was recorded to the nearest 0.5 cm. Body mass index (BMI) was then calculated by dividing the weight in kg by square meter of height. According to the WHO guidelines, subjects were categorized based on their BMI into normal weight (BMI ≤24.9), overweight (25≤ BMI ≤29.9), obese (30≤ BMI ≤34.9) and morbidly obese (BMI ≥35).[14]

Waist circumference (WC) was measured at the end of normal exhalation using an outstretched tape meter without pressure to body surfaces, and it was recorded to the nearest 0.1 cm. For subjects whose minimal WC was not easily determined due to obesity or wasting, we measured the circumference at the last vertebra, since the minimal WC is located in this area for the majority of people.[15] The greatest circumference of hip was considered as the hip circumference.

Body composition

Body composition measurement was carried out after an overnight fast by bioelectrical impedance analysis (BIA). BIA is a non-invasive and readily available test to distinguish lean body mass and fat mass by comparing conductivity and resistance in the body,[16,17] and it has previously shown to provide results in agreement with dual-energy X-ray absorptiometry (DXA) test. [18-20] Evaluation of body composition using BIA is based on the regression equation that uses resistance (R) and reactance (X_C).[21]

In the present study, BIA measurements were performed by a single-frequency technique using Quadscan™ device (Quadscan™ 4000; Bodystat, Douglas, Isle of Man, United Kingdom). Prior to measurements, subjects were asked to lie in the supine position on a flat non-conductive bed for 30 minutes wearing only light garments. Bodystat Quadscan™ has four electrodes, 2 of which were placed on the right ankle with 1 just proximal to the third metatarsophalangeal joint (+) and 1 between the medial and lateral malleoli (-). Multi-frequency currents (5, 50, 100, 200 KHz) were introduced from the (+) leads which passed through the body to the (-) leads. Percentage body fat was then calculated using the manufacturer's in-built prediction equations.[22]

Resting metabolic rate (RMR)

Since accurate measurement of RMR typically needs incorporating competent technicians and complicated costly methodologies, its application is impractical in most clinical and community settings [23] and hence prediction equations for RMR are usually used alternatively. These formulas use variables such as age, sex, height and body mass; however they can only predict 50-75% of the variability in RMR.[24] New portable devices for RMR measurement are less costly and easier to use compared to traditionally-used metabolic carts. Cosmed company has recently developed a small (20 x 24 cm) metabolic analyzer, namely FitMate™ (Cosmed, Rome, Italy), to assess oxygen and energy consumption during rest and exercise.[23] The FitMate™ metabolic system was used in the

Table 1. Common formulas used for the calculation of resting metabolic rate (Kcal/day) in women†

Formula	Equation
Mifflin	9.99×weight+ 6.25×height – 4.92×age – 161
Harris-Benedict	665 + 9.56×weight + 1.84×height – 4.67×age
Owen	795 + 7.18×weight
Schofield	
18-30 yr	14.8×weight+ 487
31-60 yr	8.1×weight+ 846
Schofield‡	
18-30 yr	13.6×weight+ 283×height+ 98
-60 yr	8.1×weight+ 1.4×height+ 448
Abbreviation§	0.95×24×weight
Cunningham¶	500+ 22×muscle mass weight

† Weight (kilogram), height (centimeter) and age (year), unless otherwise noted
‡ Schofield formula based on height (meter)
§ An abbreviated version of Harris-Benedict formula[29]
¶ Cunningham formula based on muscle mass weight (kilogram)

present study, since it has previously shown good relative validity and reproducibility for measuring RMR and appears to be an acceptable tool for use in a wide range of adult populations.[23] In a previous study, no significant differences were found between FitMate™ and Douglas bag for oxygen consumption (mean of absolute difference: 2.83 ml/min, p=0.07, r=0.97) and RMR values (mean of absolute difference: 5.81 Kcal/day, p=0.58, r=0.97). In addition, the differences between Douglas bag and FitMate™ were not related to BMI values and RMR averages (p=0.18), indicating that no systematic difference was present in the RMR estimates at the lower and higher BMI and RMR levels.[23] The RMR results from FitMate™ have shown reproducibility and accuracy in a wide range of BMI values, and has shown smaller standard error of estimate (SEE) in relation to the Douglas bag compared to several other portable devices.[25-27]

With regards to instrument calibration, it is important to note that FitMate™ does not require any complex calibration procedure except for the room air calibration which starts automatically before each test and alerts if the device is not calibrated. In addition, FitMate™ performs random controls during RMR measurements to guarantee accuracy and reliability of results over the entire tests. For further accuracy, FitMate™ was calibrated by the manufacturer representatives for the purpose of this study.

In the present research, trained dietitians used FitMate™ calorimeter for measuring RMR according to a standard protocol. Tests were conducted at 8 AM after 12 hours of overnight fasting and subjects were instructed on consuming a standard evening meal between 19:30 and 20:00 the previous day. Participants were advised to refrain from smoking, alcohol, caffeine and drugs from at least 12 hours before the study and avoid strenuous exercises from 24 h prior to the RMR measurements. Adherence to these guidelines was confirmed before the examinations.

Subjects stayed supine for 25-30 min before RMR measurements in a quiet room with a temperature between 22ºC and 24 º C. During the procedure, subjects were relaxed and stable and a mask covered their nose and mouth to measure metabolic rate oxygen consumption (VO2) for 15 minutes. Ventilation was measured using a flow meter and the fraction of oxygen in expired gases was assessed using a galvanic fuel cell oxygen sensor. RMR was then calculated from oxygen consumption using a fixed respiratory quotient (RQ) of 0.85 and estimated grams of urinary nitrogen, from a modified Weir equation as below.[28]

Weir equation: REE = [O2 consumed (liter)×3.9 produced CO2 (liter)×1.1]×1440 min/d

Predicting resting metabolic rate (RMR) by equations
RMR was predicted by various types of formulas based on subjects' weight, height, age or fat free mass[29] (Table 1).

Statistical methods
Data were analyzed using SPSS statistical package, version 16 (SPSS Inc., Chicago, IL, USA). Paired t-test was used to evaluate the difference between the predicted and measured RMR. Analysis of variance (ANOVA) was utilized to evaluate the differences of distribution of RMR across BMI categories. If one way ANOVA test was significant, post-hoc multiple comparisons (Bonferroni) was used for pairwise comparison of groups. Analysis of covariance (ANCOVA) was used to estimate mean RMR in subjects with different BMIs, after adjusting for age and weight (Marginal Means). Pearson's correlation coefficients were calculated to examine relationships among the variables. Statistical significance was set at $p<0.05$.

RESULTS

Descriptive characteristics of 187 healthy females aged 18-45 years are presented in Table 2. Mean (±SD) age and daily energy intake/RMR (EI/RMR) were 34.9±8.1 and 1.61±0.61 respectively. Table 3 shows the mean, differences and correlation coefficients between predicted and measured RMR. Pearson correlation coefficient between predicted and measured RMR ranged from 0.43 (Cunningham formula, p<0.01) to 0.62 (Owen and Abbreviation formula). The abbreviation formula overestimated RMR, while other formulas underestimated it. The underestimation was not significant for Harris-Benedict ($p=0.22$) and Cunningham ($p=0.58$) formulas which estimated RMR relatively correctly (low bias). Table 4 presents Pearson correlation coefficient of predicted RMR bias with body mass index. There was a significant correlation between Mifflin (r=0.35; $p<0.01$) and Harris-

Table 2. Mean and standard deviation (SD) of anthropometric indexes and resting metabolic rate (RMR) in 187 Iranian females

Variables	Mean	SD
Age (yr)	34.9	8.1
Energy intake (kcal/day)	2281	730
Body weight (kg)	68.9	14.3
Height (cm)	158	6.1
Body mass index (kg/m^2)	27.7	5.8
Waist circumference (cm)	82.2	13.2
Hip circumference (cm)	106	10.4
Measured RMR	1473	296
Energy intake to RMR ratio (EI/RMR)	1.61	0.61

Table 3. Mean and standard deviation (SD), Pearson correlation coefficient and difference between predicted and measured resting metabolic rate (RMR) (bias) in Iranian females

	Mean±SD†	Bias‡	*p*-value§	correlation coefficient	*p*-value¶
Measured RMR	1473±296.1				
Predicted RMR					
Mifflin	1338±162	-134± 256	<0.01	0.50	<0.01
Harris-Benedict	1450±131	-21.9 ± 244	0.22	0.58	<0.01
Owen	1290± 102	-182± 245	<0.01	0.62	<0.01
Schofield††	1418±148	-54.1±243	<0.01	0.58	<0.01
Schofield‡‡	1415±145	-57.1± 241	<0.01	0.59	<0.01
Abbreviation	1574±325	102±271	<0.01	0.62	<0.01
Cunningham	1461±125	-10.9±267	0.58	0.43	<0.01

† Kcal/day. ‡Difference between predicted and measured RMR. §*p*-values are obtained by paired t-test analysis. ¶*p*-values are obtained by Spearman correlation coefficient. ††Weight based formula. ‡‡Weight and height based formula

Table 4. Pearson correlation coefficient of predicted resting metabolic rate (RMR) bias with body mass index

Formula	Bias†,‡	correlation coefficient	*p*-value
Mifflin	-134± 256	0.35	<0.01
Harris-Benedict	-21.9 ± 244	0.18	<0.05
Owen	-182± 245	0.08	0.27
Schofield§	-54.1±243	0.08	0.27
Schofield¶	-57.1± 241	0.08	0.27
Abbreviation	102±271	0.04	0.61
Cunningham	-10.9±267	0.14	0.06

†Values are mean ±SD. ‡ Difference between predicted and measured RMR. §weight based formula. ¶Weight and height based formula

Table 5. Mean and percentage bias of predicted and measured resting metabolic rate (RMR) in Subjects with different body mass indexes†,‡

	Normal weight	Overweight	Obese	Morbidly obese
Measured RMR	1310±224	1454±237	1571±263	1853±395
Predicted RMR				
Mifflin*	1242±85.5**	1332±93.2***	1398±118***	1538±364**
Bias§, (Mean±SD)	-67.7±212	-122±230	-173±247	-316±421
Bias¶, %	13.5±11.3§§	14.9±13.2§§	17.4±12.2§§	40.3±77.9§§
Harris-Benedict*	1349±66.1	1440±69.8	1513±90.2	1682±217
Bias§, (Mean±SD)	38.8±211	-14.1±227	-58.0±246	-172±346
Bias¶, %	11.9±10.3‡‡	12.1±10.4§§	13.1±9.6§§	20.7±13.3§§
Owen*	1188±46.9***	1291±42.8***	1354±50.1***	1484±107***
Bias§, (Mean±SD)	-122.7±210	-163±223	-217±249	-369±347
Bias¶, %	15.0±13.4§§	16.2±13.9§§	19.3±14.3§§	28.2±18.4§§
Schofield††*	1287±85.3	1415±60.2	1497±92.6**	1686±197
Bias§, (Mean±SD)	-23.3±207	-39.1±229	-73.9±249	-167±308
Bias¶, %	11.8±10.6§§	12.4±10.9§§	13.9±9.9§§	20.4±13.1§§
Schofield‡‡,*	1285±87.4	1413±60.4	1494±84.9**	1678±183
Bias§, (Mean±SD)	-25.0±207	-41.9±227	-77.4±247	-175±365
Bias¶, %	11.9±10.5§§	12.1±10.9§§	13.8±9.9§§	20.3±13.2§§
Abbreviation*	1247±149**	1575±136***	1776±159***	2187±341***
Bias§, (Mean±SD)	-63.2±214	120.8±222	205±252	334±351
Bias¶, %	13.9±11.5§§	12.6±9.8‡‡	14.4±10.1‡‡	17.4±13.3‡‡
Cunningham*	1393±126**	1470±83.7	1507±109	1545±171***
Bias§, (Mean±SD)	82.7±244	16.3±224	-64.3±240	-308±362
Bias¶, %	13.6±10.9‡‡	11.4±10.3‡‡	12.7±10.0§§	27.0±15.9§§

†Values are mean ±SD. ‡Normal weight: BMI≤24.9, Overweight: 25≤ BMI≤ 29.9, Obese: 30≤ BMI≤ 34.9, Morbidly obese: BMI≥ 35[15]. §Difference between predicted and measured RMR. ¶[(RMR predicted- RMR measured) × 100]/RMR predicted. ‡‡: Overestimation §§ underestimation. ††Weight based formula. ‡‡Weight and height based formula. *$p< 0.01$ (*p*-value was defined as statistical difference between normal-weight, overweight, obese and morbidly obese subjects in ANOVA Test). **$p< 0.05$, ***$p<0.01$ (*p*-value was defined as statistical difference between predicted and measured RMR in a two-tailed paired t-test)

Benedict (r=0.18; $p<0.05$) formulas with BMI.

Table 5 shows mean (SD) bias and bias percentages for predicted and measured RMR in subjects with different BMI values. As presented, Harris-Benedict formula estimated RMR with Low bias in all BMI categories (normal weight, overweight, obese and morbidly obese). On the other hand, Mifflin and Owen formulas significantly underestimated RMR in all BMI groups, while Abbreviation formula overestimated RMR significantly in all but normal-weight individuals. Furthermore, both Schofield formulas (weight-based and weight- and height-based) correctly estimated RMR in individuals with normal weight, overweight and morbid obesity; but had bias in estimating RMR among obese women ($p<0.05$). Finally, the Cunningham formula estimated RMR correctly in overweight and obese women, but were with error in normal weight and very obese subjects. Overall, all formulas overestimated RMR with high error in obese Iranian women ($p<0.05$) and RMR values increased significantly by moving from the lowest BMI categories to the highest ($p<0.01$). However, after mutual adjustment for age and weight, these differences were not significant in any of the BMI categories ($p=0.55$).

DISCUSSION

The aim of the present study was to evaluate the validity of RMR estimating formulas in subjects with different BMI values. Using the equations that utilize easily measurable anthropometric indexes (weight, height and lean body mass) to calculate RMR, the best formula for predicting RMR in Iranian women with different BMIs was shown to be the Harris-Benedict formula. In normal weight, overweight and morbidly obese subjects, Schofield formulas could report a correct estimate; albeit in obese groups they had prediction bias. In addition, the Cunningham formula estimated RMR with high precision in overweight and obese groups but not in normal weight and extremely obese individuals. Other formulas (Mifflin, Owen and Abbreviation) did not predict RMR accurately in any of the BMI categories ($p<0.05$)

Based on these results, the Harris-Benedict formula is the most valid equation for predicting RMR in Iranian women. This might be due to the social similarity of this group of Iranian women with those who participated in the study that defined the Harris-Benedict formula.[30] The Harris-Benedict formula was developed by performing a survey on 136 men aged 16-63 y and 103 women aged 25-74 y with different weights over a period of 10 years (1907-1917). Despite the fact that this formula is timeworn, it is still used in clinical assessments. Several studies have reported bias associated with the use of this formula[10] and in the present study we observed an underestimation error, although it was not a significant outcome. The Harris- Benedict formula has been shown to correctly estimate RMR in 45-80% of individuals with normal body weight [13,31] and 38-64% of obese subjects;[13,31-33] therefore in situations where RMR measurement is impossible, it can be used for predicting RMR with low degree of bias.

According to Weijs et al.[11] Harris- Benedict and Mifflin formulas are acceptable for use in people with a BMI range of 18.5 to 50. In addition, some studies have shown that the Harris- Benedict formula is usable in a wide weight range especially in extremely obese individuals.[11,34] Likewise, Frankenfield *et al.*[13] have suggested to use the Harris-Benedict formula preferably for morbidly obese individuals (BMI>40) and at the second level for those with BMI 30-40.

De Lorenzo *et al.*[12] have suggested that the Harris-Benedict and Schofield formulas are applicable for estimating RMR in normal and overweight subjects, although they underestimate RMR in obese individuals. This is in line with our results and Antonini *et al*'s study[35] in which applying the Schofield formulas to obese subjects was associated with underestimation error. The Schofield formulas have been developed based on a young and physically active population [36,37] while our sample comprised of mainly moderately-active middle-aged women, which could partly explain the estimation error associated with use of this formula in our population.[2,35,38]

The Schofield formulas have not been proved as suitable in very obese individuals (BMI>45) and are less applicable for subjects with BMI range of 30-40. The Mifflin formula, on the other hand, is claimed to be suitable for extremely obese men and women.[39]

In the present study, the abbreviation formula overestimated RMR and since this formula is frequently used in most health clinics, this might cause the predicted RMR to be more than actual needs, which leads to high energy estimations and ineffective weight loss programs.

Generally, measured RMR in the present study was higher than the predicted values obtained from formulas, except for the predicted RMR from the Abbreviation formula, which was higher than the measured value ($p<0.01$). In addition, the underestimation error for the Harris-Benedict and Cunningham formulas were not statistically significant ($p>0.05$). These findings are in line with several studies[11,12,40,41] and in contrast with some others.[4,10] This could be due in part to the inherent discomfort (or some other effects) associated with the original technique that cannot be overcome by training.[42] In addition, use of different RMR and body composition measurement methods, instrument errors and biological factors (BMI, race, body mass) across the different studies could also explain the dicrepancies.[10]Although RMR values obtained from indirect and direct calorimetery have shown close agreements,[18-20] it is very likely that various measurement instruments used in different studies have been partly responsible for the difference in results.[20,23] In addition, the systematic differences between the predicted and measured RMR could be explained by comparison of original population from which formulas were developed and other populations. The higher measured RMR in the present study could also be explained by higher BMI values of subjects in the present study compared to the previous studies.[37,43]

In this population, bias of predicted RMR in the Mifflin and Harris-Benedict formulas was influenced by BMI values. There was a positive correlation between bias and BMI, so that increasing BMI values led to increase in bias. This is in agreement with Frankenfield and Rowe *et al.*'s study in which they suggested BMI and bias to be directly related to each other in estimating RMR and bias of calculating RMR in obese individuals to be higher than others using different prediction equations.[13]

We measured RMR under controlled situations by considering various factors. For example, all women were at the same phase in their monthly menstrual cycle in order to reduce its metabolic effects. However, our study was performed in a small sample and it is suggested that, other studies are designed and carried out with larger samples in order to capture more accurate results.

Although we found that the Harris-Benedict formula estimates RMR with less bias, generally using prediction equations might lead to bias in estimating RMR compared to direct RMR measurements. Several studies have claimed that energy requirement of people from developing countries are low;[44] and using standard equations for estimating RMR in these countries might lead to greater bias and overestimation of energy needs. However, even in developed countries, these formulas are criticized for use, especially in obese subjects since most of them are weight-based and not FFM-based. It is suggested that due to high discrepancies between measured and predicted RMR, RMR be measured rather than estimated, in situations where reliable individual values are required.

CONCLUSION

In the present study, Harris-Benedict, Schofield, Mifflin, Owen and Cunningham formulas underestimated RMR but the Abbreviation equation overestimated it. The Harris- Benedict formula estimated RMR more precisely compare to other formulas. In situations where the exact measurement of RMR is targeted, it is suggested that more credible methods instead of equations are used.

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AUTHOR DISCLOSURES

None of the authors had any personal or financial conflicts of interest.

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Original Article

Validity of predictive equations for resting energy expenditure among Iranian women

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估計伊朗女性休息代謝率公式之效度

目的：測量伊朗女性之休息代謝率(resting metabolic rate, RMR)，同時評估適用於正常與肥胖個體的休息代謝率公式之效度。方法：此橫斷型研究，共 187 位年齡介於 18-45 歲之間之健康女性參與。收集體位資料，及在空腹狀態下，利用間接測卡法(indirect calorimetry)測得 RMR。並根據個案之身高、年齡、體重及瘦體組織等資料，使用各種預測公式，計算對應之 RMR。體組成資料則是利用生物電阻法(bioelectric impedance analysis, BIA)獲得。結果：實測的 RMR 平均為 1473 ± 296 kcal/day。使用較簡單的公式傾向高估 RMR，而其他公式則會低估。不論受測者的體位分類（正常體重、過重、肥胖和病態肥胖），Harris-Benedict 公式皆能有效估計 RMR。兩個 Schofield 方程式在正常、過重及病態性肥胖者能有效估計 RMR，然而 Cunningham 方程式，只有在過重及肥胖者才能有效估計 RMR。另外結果也發現，與正常體重的女性相比，過重與肥胖的女性有較高的 RMR ($p<0.01$)，雖然在調整年齡與體重後，此差異不顯著。結論：以群體為單位，Harris-Benedict 公式能有效估計體位介於正常至病態性肥胖的伊朗女性。然而，在個人為單位下，誤差可能會提高，因此實測仍優於估計公式。

關鍵字：休息代謝率、預測公式、效度、婦女、能量代謝