BASAL ENERGY EXPENDITURE IN MEN LIVING IN GOIÂNIA

EXERCISE AND SPORTS MEDICINE CLINIC

ORIGINAL ARTICLE

Arícia Motta Arantes Lustosa[1]
Ana Paula Nunes Bento[(1)]
Fernando Policarpo Barbosa[2]
Eliane De Abreu Soares[3]
Estélio Henrique Martin Dantas[4]
José Fernandes Filho[5]

1. Nutrition – Goiânia, GO, Brazil.
2. Stricto Sensu Graduation Program in Health Sciences of the Federal University of Rio Grande do Norte – Natal, RN, Brazil.
3. State University of Rio de Janeiro – Rio de Janeiro, RJ, Brazil.
4. Stricto Sensu Graduation Program in Nursing and Biosciences of the Federal University of Rio de Janeiro State - Rio de Janeiro, RJ, Brazil
5. Federal University of Rio de Janeiro – Rio de Janeiro, RJ, Brazil.

Mailing address:
Av. T-1 n. 2.620-A – S. Bueno
74215-022 – Goiânia, GO, Brasil
E-mail: arícia@terra.com.br

ABSTRACT

Introduction: The Basal Energy Expenditure (BEE) is the amount of energy necessary to the human body to keep the normal physiological processes and homeostasis. Currently, BEE is calculated from equations based on the North American and/or European population. Objective: To compare the Harris-Benedict, Food and Agriculture Organization and Institute of Medicine equations with indirect calorimetry in men living in Goiânia. Methods: Forty-four male volunteers with average age of 29.80, standard deviation – SD = 6.21 years; stature 1.79, SD = 0.06m; weight 77.79, SD = 8.49 kg; BMI 24.30, SD = 1.96 kg/m^2; body fat 15.84, SD = 4.49% and waist circumference 80.48, SD = 5.89 cm were evaluated. BEE was determined by direct gas analyses; therefore, the VO2000 gas analyzer was used. Results: There was significant difference ($p < 0.05$) for the BEE estimated by the Harris-Benedict (1824.66 ± 138.25 kcal/day) and Food and Agriculture Organization (1821.77, SD = 115.39 kcal/day) equations when compared to the BEE acquired by the indirect calorimetry (1709.81, SD = 329.75 kcal/day). BEE estimated by the IOM/2005 equation (1791.81, SD = 329.74) did not present significant difference when compared to the measured BEE. Conclusion: The Food and Agriculture Organization and Harris-Benedict equations can overvalue the BEE of healthy young men with characteristics similar to those recorded on this work.

Keywords: BEE, indirect calorimetry, equations.

INTRODUCTION

The Basal Energy Expenditure (BEE) represents the greatest part of the daily energetic cost in humans (50 to 70%) and it is the amount of energy needed for the body to keep the normal physiological processes and homeostasis. These processes include the cardiovascular and respiratory at rest, gastrointestinal and renal functions, the energy used by the central nervous system, cellular homeostasis as well as the remaining biochemical reactions involved in the maintenance of the basal metabolism[-3].

It is directly influenced by fat-free mass, age, sex, body composition and genetic factors. Other processes such as the nervous system activity, the thyroid hormones, the protein turnover and the sodium-potassium pump also contribute to a BEE variation among individuals[4-7].

The BEE may be measured by direct or indirect calorimetry, which is the amount of the energetic cost from the respiratory exchanges (oxygen consumption and carbon dioxide production), associated with the oxidation of the main energetic substrates: carbohydrates, proteins, lipids and alcohol[6].

Many mathematical equations using variables of easy measurement and low cost, such as age, height and total body mass have been developed for BEE estimation[5]. Among these equations, we highlight the ones by Harris and Benedict[3], FAO/85[8] and Institute of Medicine (IOM)[9], all of them widely spread and studied.

The BEE is usually measured in the morning, under ten to 12 hour-fasting, with six to eight hours of sleep, at supine position, in environment with controlled temperature and humidity, after 15 to 30 minutes of rest. The measurement of the gas exchanges is obtained in the 20 to 30 subsequent minutes, during which the individual should remain at supine position, awake and completely relaxed. The Basal Energy Expenditure (BEE), on the other hand, is measured in the afternoon, at sitting position, three to four hours after the last meal, and provides an estimation of the energetic consumption value (kcal/day) which is from 10% to 20% higher than the BEE[5,9,10-12], mainly derived from the Thermal Effect of the Food (TEF).

Studies conducted by different groups of researchers in many parts of the world have found variations between the BEE estimation obtained by mathematical equations and the ones determined by indirect calorimetry. These differences contribute to the quality loss of diet or physical exercise programs, which may be harmful to the population's health. The inadequation of the BEE estimation equations for specific populations, such as the Brazilian and Australian ones, ends up bringing dissatisfaction and discredit to the given services besides disturbing their aims, as weight body composition control[9-15].

The aim of this study was to compare the results of the BEE estimated by mathematical equations proposed by Harris-Benedict[3], FAO/85[6] and IOM 2005[7], with the values determined by indirect calorimetry in young male volunteers, residents of the city of Goiânia.

METHODS

This comparative research[16] was approved by the Ethics Committee of the Castelo Branco University. 44 male volunteers selected

by simple convenience method in a universe of 900 men, members of a club in the city of Goiânia were evaluated. Inclusion criteria were: absence of chronic diseases; absence of smoking habit; absence of loss or gain diet in the last six months and no use of pharmacological substances or ergogenic food supplements which are considered metabolism accelerators.

The work was performed after consent given by the individuals, who received information about all the procedures involved in the research. The evaluations were carried out in the Flex Center of Nutrition/ Qualitatis Vitae in Goiânia.

Body composition was evaluated through data of body density and body fat percentage. Body density was calculated using the protocol of seven skinfolds, as described by Pollock and Wilmore[17]. Body fat percentage was evaluated with application of reference values by Pollock and Wilmore[17].

Basal Energy Expenditure (BEE) was obtained by indirect calorimetry and mathematical equations (FAO/85, Harris-Benedict and IOM/2005). The indirect calorimetry was measured with the VO2000 metabolic gas analyzer (MEDGRAPH, USA), which was calibrated with gas with known composition (16% O_2 and 5% CO_2) before each measurement. BEE was calculated based on the mean of the O_2 consumption and CO_2 release, applying the formula $[(3.9 \times O_2) + (1.1 \times VCO_2)] \times 1.440$[18].

BEE measured by indirect calorimetry required the individuals to refrain from practicing intense physical activity for 24 hours and drinking alcohol. Additionally, they should remain 12 hours at fasting. After eight hours of sleep, the individuals went to the evaluation premises being still at fasting from liquid or solid food, without having engaged in any kind of activity, including having a bath. The volunteers were placed at rest for 30 minutes before the collection. Subsequently, during further 30 minutes, they remained connected to the gas analyzer through a mouth piece, with a nasal clip on to avoid they breathe through their noses[11,19].

The BEE values obtained by indirect calorimetry through the equations were expressed as mean and standard deviation (SD). Data normality was evaluated through application of the Kolmogorov-Smirnov test. The Boferrone treatment with repeated measures with correction was used to verify the possible differences between the BEE obtained by indirect calorimetry and by the studied estimation equations. Subsequently, analysis of the Bland and Altman residual scores for confidence level of 95% was performed ($p < 0.05$).

RESULTS

The evaluated individuals presented mean age of 29.8 years with range between 18 and 39 years. Mean weight, height and waist circumference were 77.79 kg (SD = 6.21); 1.79 m (SD = 0.06); 80.48 cm (SD = 5.89), respectively. Concerning body composition, mean BMI and fat percentage were 24.3 kg/m^2 (SD = 1.96) and 16% (SD = 5.5), respectively.

The values concerning the BEE measurement by indirect calorimetry and the ones obtained by the mathematical equations are presented in table 1. Statistical analysis of the means presented significant difference: for Wilks'Lambda of F (19.295) = 41.000; p:0.01 with significance level of $p < 0.05$ between indirect calorimetry and the one estimated by the Harris-Benedict equation ($p = 0.01$) for standard error of 20.8 kcal, with the same behavior being observed ($p = 0.01$) between indirect calorimetry and the FAO/85 equation, where standard error was of 17.4 kcal. The mean error estimated by the IOM 2005 equation did not present difference when compared with indirect calorimetry ($p = 0.09$), being observed the lowest standard error of 16.7 kcal.

The residual scores results represented by the difference between indirect calorimetry and the studied equations enabled us detect that the FAO/85 equation overestimated mean of 11.66% of the BEE of the volunteers. The Harris-Benedict equation presented mean percentage difference of 10.07% for the BEE determined by indirect calorimetry, corroborating hence the tendency to overestimate the reference values.

Table 1. Values of the Basal Energy Expenditure obtained by indirect calorimetry and estimated by the IOM/2005, FAO/85 and Harris-Benedict equations for 44 adult and young men from Goiânia, Goiás.

	Mean ± standard deviation (kcal)	Minimum (kcal)	Maximum (kcal)
Indirect calorimetry	1.710 ± 330	1.067	2.416
IOM, 2005	1.791 ± 111	1.583	2.039
FAO, 85	1.822 ± 115	1.631	2.083
Harris-Benedict	1.825 ± 138	1.557	2.168

IOM 2005: Institute of Medicine (2005)[9]; FAO 85: Food and Agriculture Organization (1985)[8]; Harris-Benedict (1919)[3].

DISCUSSION

It is possible to observe through the comparison of the anthropometric results of the present study and other studies that results similar to the ones reported by Piers *et al.*[12] and Wahrlich *et al.*[11] for Australian and Brazilian men, respectively were evidenced.

The values concerning the BEE measurement by indirect calorimetry indicate that the Harris-Benedict and FAO/85 equations overestimated the basal energy expenditure in men residents of the city of Goiânia. These results are in agreement with the ones found by other authors[5,10,11,13,20-22] who also observed statistically significant differences of BEE obtained by indirect calorimetry and the one estimated by the referred equations. An interesting piece of information which should be mentioned is that the individuals evaluated by Cruz *et al.*[13] and Clark and Hoffer[22], as well as the ones in the present study, lived in tropical regions. These sites present high temperatures, which can represent reduction of 2 to 5% in the total energy expenditure of sedentary individuals when compared with the ones who live in tropical climate (IOM, 2005)[9].

Once the tendency to BEE overestimation was verified by the equations, the difference between the measured and estimated values was evaluated. It was observed that the difference between the measured and estimated BEE found in the present study was lower than the values obtained by Wahrlich and Anjos[10] (Harris-Benedict: 17%; FAO/85; 13.5%) and by Cruz *et al.*[13] (Harris-Benedict: 19%; FAO/85 12.5%), who researched the BEE in Brazilian women, indicating higher inadequation for the female population.

It was observed that the FAO/85 and Harris-Benedict equations presented the same behavior for the male group evaluated. However, Valencia *et al.*[23] found lower values for the BEE in a study conducted with 32 Mexican men aged between 18 and 40 years, evidencing BEE overestimation of 8.2% by the FAO/85 equation[6]. Other studies

reported similar results for healthy adult men (9%)[22] and for men and women (11%)[10], confirming the tendency of overestimation of the BEE values when using the available equations.

The IOM[9] proposes two formula equations: one for healthy individuals and another for overweighed or obese individuals. Regarding the studied population, the IOM/2005 equation was adequate to the BEE estimation for being close to the values measured by indirect calorimetry. A different result was found by Wahrlich *et al.*[10] who observed values estimated by the IOM equation, overestimating the BEE in 11.3% for Brazilian women and in 15.1% for Brazilian men who lived in the United States, when compared with the values obtained by indirect caloriemtry.

CONCLUSION

Thus, it is concluded that the Harris-Benedict and FAO/85 equations tend to overestimate the BEE value for young and healthy men, similarly to the characteristics presented in the study here. The IOM/2005 equation on its turn, results in BEE values close to the measured ones, when considering the same public.

Further studies are suggested, especially having the Brazilian population as target.

All authors have declared there is not any potential conflict of interests concerning this article.

REFERENCES

1. Ruiz JR, Ortega BO, Rodriguez G, Alkorta P, Lambayan I. Validity of resting energy expenditure predictive equations before energy-restricted diet intervention in obese women. PLos ONE2011;9:1-11.
2. Wilmore JH, Stanford PR, Hudspeth LA, Gagnon G, Daw EW, Leon AS, et al. Alterations in resting metabolic rate as a consequence of 20wk of endurance training: the HERITAGE Family Study. Am J Clin Nutr 1998;68:66-71.
3. Harris JA, Benedict FG. A Biometric Study of Basal Metabolism in man. Boston: Carnegie Institution of Washington, 1919.
4. Piers LS, Soares MJ, McCormack LM, O'dea K. Is there evidence for an age-related reduction in metabolic rate? J Appl Physiol 1998;85:2196-204.
5. Frankenfield D, Roth-Yousey L, Compher C. Comparison of predictive equations for resting metabolic rate in healthy nonobese and obese adults: a systematic review. J Am Diet Assoc 2005;105:775-9.
6. Murgatroyd PR, Shetty PS, Prentice AM. Techniques for the measurement of human energy expenditure: a practical guide. Int J Obes 1993;17: 549-68.
7. Weijs PJM, Kruizenga HM, Dijk AE, Barbara S, Meij BS, Langius, JAE, et al. Validation of predictive equations for resting energy expenditure in adult outpatients and inpatients. Clin Nutr 2008;27:150-7.
8. Food and Agriculture Organization; World Health Organization; United Nations. Energy and protein requirements. WHO Technical Report Series 724. Geneve: World Health Organization, 1985.
9. Institute of Medicine. Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (Macronutrients). Food and Nutrition Board, Institute of Medicine. Washington (DC): The National Academies, 2005.
10. Wahrlich V, Anjos LA. Validação de equações de predição da Taxa Metabólica Basal em mulheres residentes em Porto Alegre, RS, Brasil. RevSaúde Pública 2001;35:39-45.
11. Wahrlich V, Anjos LA, Going SB, Lohman TG. Basal metabolic rate of Brazilians living in the Southwestern United States. Eur J Clin Nutr 2007;61:290-4.
12. Piers LS, Diffey B, Soares MJ, Frandsen SL, McCormack LM, Lutschini MJ, et al. The validity of predicting the basal metabolic rate of Young Australian men and women. Eur J Clin Nutr 1997;51:333-7.
13. Cruz CM, Silva AF, Anjos LA. A taxa metabólica basal é superestimada pelas equações preditivas em universitárias do Rio de Janeiro, Brasil. Arch Latinoam Nutr 1999;49:232-7.
14. Reichman CA, Shepherd RW, Trocki O, Cleghorn GJ, Davies PSW. Comparison of measured sleeping metabolic rate and predicted basal metabolic rate during the first year of life: evidence of bias changing with increasing metabolic rate. Eur J Clin Nutr 2002;56:650-5.
15. Zenk JL, Leikan SA, Kassen LJ, Kuskowski MA. Effect of Lean System 7 on metabolic rate and body composition. Nutrition 2005;21:179-85.
16. Thomas JR, Nelson JK. Métodos de Pesquisa em Atividade Física. Porto Alegre: Artmed; 2002.
17. Pollock ML, Wilmore JH. Exercícios na saúde e na doença. Rio de Janeiro: Medsi; 1993.
18. Weir JB. New methods for calculating basal metabolic rate with special reference to protein metabolism. J Physiol 1949;109:1-9.
19. Arantes AM, Albernaz A, Silva MS, Fernandes Filho J. Influência do acessório na medida da taxa metabólica basal através da calorimetria indireta. Fit Perf J 2003;5:37-41.
20. Boullata J, Williams J, Cottrell F, Hudson L, Compher C. Accurate determination of energy needs in hospitalized patients. J Am Diet Assoc 2007;107:393-401.
21. Compher C, Cato R, Bader J, Kinosian B. Harris-Benedict equations do not adequately predict energy requirements in elderly hospitalized African Americans. J Natl Med Assoc 2004;96:209-14.
22. Clark HD, Hoffer LJ. Reappraisal of the resting metabolic rate of normal young men. Am J Clin Nutr 1991;53:21-6.
23. Valencia ME, Moya SY, McNeil G, Haggarty P. Basal metabolic rate and body fatness of adult men in northern Mexico. Eur J Clin Nutr 1994;48:205-11.