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Validez de las ecuaciones predictivas del gasto energético en reposo en la población ecuatoriana

Validity of predictive equations of energy expenditure at rest in the Ecuadorian population

Validade das equações preditivas do gasto energético em repouso na população equatoriana

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Resumen

ANTECEDENTES: La calorimetría indirecta (IC) es un método utilizado para calcular el gasto energético en reposo (GER). Es una técnica no invasiva y muy fiable en el área clínica pero no disponible en la práctica diaria del dietista nutricionista. OBJETIVO: Validar las diferentes ecuaciones de predicción del RGE con la Calorimetría indirecta y proponer una ecuación de predicción desarrollada con la población adulta sana o aparentemente sana y en relación a diferentes componentes corporales como la masa libre de grasa. METODOLOGÍA: Se realizó un estudio transversal. La Tasa Metabólica en Reposo se midió mediante calorimetría ventilatoria indirecta, edad, sexo y composición corporal, se produjo una ecuación de predicción por regresión lineal múltiple, validada por precisión y concordancia con el método de Bland-Altman. RESULTADOS: La población participante fue de 38 individuos con una edad promedio de 24 (5.5), el Índice de Masa Corporal (IMC) promedio 24.5 (3.7) y la masa muscular con un promedio de 46.8 (9.5), La fórmula de predicción se refiere solo a la variable masa muscular como independiente y GER como dependiente. CONCLUSIÓN: La fórmula desarrollada para la predicción del requerimiento calórico en reposo en adultos aparentemente sanos tuvo una buena concordancia y precisión con los valores estimados por el método de calorimetría indirecta.

Palabras clave: calorimetría indirecta; RGE; ecuación de predicción; masa muscular.

Abstract

BACKGROUND: Indirect calorimetry (CI) is a method used to calculate energy expenditure at rest (GER). It is a non-invasive and very reliable technique in the clinical area but not available in the daily practice of the dietitian nutritionist. OBJECTIVE: To validate the different prediction equations of the GER with the indirect Calorimetry and to propose a prediction equation developed with the healthy or apparently healthy adult population and in relation to different body components such as fat-free mass. METHODOLOGY: A cross-sectional study was carried out. The Resting Metabolic Rate was measured by indirect ventilatory calorimetry, age, sex and body composition, a prediction equation was produced by multiple linear regression, validated by precision and concordance with the Bland-Altman method. RESULTS: The participating population was 38 individuals with an average age of 24 (5.5), the average Body Mass Index (BMI) 24.5 (3.7), and muscle mass with an average of 46.8 (9.5), The prediction formula refers only to variable muscle mass as independent and GER as dependent. CONCLUSION: The formula developed for the prediction of caloric requirement at rest in apparently healthy adults had a good concordance and accuracy with the values estimated by the indirect calorimetry method.

Keywords: indirect calorimetry; GER; prediction equation; muscle mass.

Resumo

ANTECEDENTES: La calorimetría indirecta (IC) é un método utilizado para calcular o gasto energético en reposo (GER). É uma técnica não invasiva e muy fiável na área clínica pero não disponível na prática diaria del dietista nutricionista. OBJETIVO: Validar as diferentes equações de predição da RGE com a Calorimetria indireta e proponente uma execução de predição desarrollada com a população adulta sana ou aparentemente sana e em relação a diferentes componentes corporais como a masa libre de grasa. METODOLOGÍA: Se realizó un estudio transversal. La Tasa Metabólica en Reposo se midió mediante calorimetría ventilatoria indirecta, edad, sexo y composição corporal, se produz uma ecuación de predicción por regresión lineal múltiple, validada por precisão y concordancia con el método de Bland-Altman. RESULTADOS: A população participante fue de 38 indivíduos com um edad promedio de 24 (5,5), el Índice de Massa Corporal (IMC) promedio 24,5 (3,7) y la masa muscular con un promedio de 46,8 (9,5), La formula de predicción se refiere solo a la variable masa muscular como independiente y GER como dependiente. CONCLUSÃO: A fórmula desarrollada para a previsão do requerimento calórico em adultos aparentemente sanos tuvo una buena concordancia y precisión con los valores estimados por el método de calorimetría indireta.

Palavras-chave: calorimetría indira; RGE; ecuación de predicción; masa muscular.

Introducción

There are several factors that influence the energy expenditure at rest, GER, and determine their significant variation from one person to another, among these factors are body composition, especially the percentage of muscle mass, age, sex, hormone production, level of physical activity, physiological state, drugs that alter metabolism and pathology (1,30). The determination of energy requirement for the GER is the initial and basic component in the nutritional care process, for this purpose, prediction equations based on anthropometric data that are easy to implement with low complexity and cost, but not precise, and developed in different populations. The most accurate methods are usually complex, expensive, invasive and not available for general use, especially in the outpatient setting.

Indirect calorimetry, IC, is a method used to calculate energy expenditure. It is a non-invasive and very reliable technique commonly used in the clinical area. Through IC, basal energy expenditure is estimated indirectly using the caloric equivalents of oxygen (O2) consumed and carbon dioxide (CO2) produced (2,3). This energy produced corresponds to conversion through chemical energy of nutrients ingested and stored as ATP, the energy that is dissipated as heat during the oxidation process. Thus, the O2 consumed oxidizes the energy substrates of macronutrients (proteins, carbohydrates, and fats) and CO2 eliminated by respiration, makes it possible to calculate total energy produced by nutrients (2)

This principle is based on the exchange of gases; the respiration in a calorimeter produces a depletion of O2 and accumulation of CO2, this amount of O2 consumed, and CO2 produced is determined by multiplying ventilation frequency, of 1L/sec, by the change in gas concentration that has a value of 1.0 for the oxidation of carbohydrates, 0.81 for protein and 0.71 for lipids (4.5).

Estimating and understanding these values of resting energy expenditure allows the nutritionist to provide adequate nutritional management to the individual (6-10), balanced in relation to food consumption and energy expenditure. Prediction equations, in general, have been developed and validated using data collected from individuals of different ages, sex, ethnicities, body compositions, physical activity levels, and other physical characteristics, therefore, the prediction equations may not be So accurate when applied to populations other than those used for their development, so the usefulness, validity, and reliability of the prediction formulas must be evaluated when the population in which they wish to apply them differs considerably from the populations in which these formulas were developed, several studies show that there are a considerable difference and an error of estimation that is necessary to know for a correct application in clinical practice (11,20). In order to improve the predictive capacity of the formulas have included different variables and proposed the use of fat-free mass because it explains from 53% to 88% of the variation in the rate of metabolism at rest (12,21-29).

When reviewing scientific literature, no studies have been found that validate the different GEE prediction equations in Ecuadorian population, especially with elements of body composition compared to more precise and direct measurement methods such as indirect calorimetry. The purpose of this study was to develop a prediction equation of GER in healthy or apparently healthy adult population that uses different body components such as fat-free mass and validate it in relation to GER by indirect calorimetry and establish its accuracy and concordance in comparison with other prediction formulas commonly used.

Methods

A cross-sectional study was carried out, the sample size was calculated for a correlation coefficient r between indirect Calorimetry and predictive model of 0.850, a confidence level of 95% and a maximum error of 0.10, 10% was added for possible losses, so the final size was 38 subjects. We consecutively selected 15 men (39.5%) and 23 women (60.5%), university students who voluntarily participated in the Polytechnic School of the Litoral (ESPOL) in 2017 second therm. They responded to recruitment messages through web announcements of the Nutrition Career of ESPOL. Inclusion criteria: apparently healthy subjects, with no known pathology that could affect their basal metabolic rate, not having drinks with caffeine or smoking. Pregnant women who knew about their condition and/or nursing mothers were not part of the study. Informed consent was obtained from all participants, the protocol was approved by the Institutional Review Committee and Helsiki Declaration principles were followed (13).

The Resting Metabolic Rate, TMR, was measured by closed-circuit ventilatory indirect calorimetry with a portable MedGem® calorimeter and following the manufacturer's protocol, this procedure determines the caloric requirement based on oxygen consumption (VO2), it is calculated routinely from oxygen consumption using a constant respiratory coefficient of 0.85%, which considers a clinically acceptable error of 2.5%. The TMR is also known as resting energy expenditure (GER) and calculated using the Weir equation: Heat output = 3,941 x oxygen consumption in liters +1.106 carbon dioxide produced in liters -2.17 x urinary nitrogen in grams. This equation has been modified by Vo2 and Vco2 for indirect calorimetry. RMR = [(3.9 x Vo2) + (1.1 x Vco2)] 1440 (14.15). The difference in energy expenditure calculations does not differ significantly when it is done with or without nitrogen excretion values, the Weir equation omits the urinary nitrogen and the result is expressed in Kcal/day (16,17).

The participants reported whether they had observed the procedure instructions, tests and did not present any respiratory disease at the time of the evaluation. Before each procedure, they were in absolute rest in the nutritional assessment room with dim lighting and controlled the temperature of 22 degrees Celsius, with a medical gown and seated position. All participants were warned not to perform physical activity with a minimum time of 4 hours and with minimum rest of 20 minutes before the test. Those evaluated were in the post-absorptive feeding period, the test was performed after 2 pm and their last meal was breakfast, participants did not consume caffeine at least 12 hours before the test and/or did not report having consumed alcohol 24 hours. The duration of the test was 10 minutes (5-10 min). It was recommended that patients didn't smoke or drink caffeine on the day of the evaluation. The test was controlled by the researchers. The procedure was considered valid if the device did not report an-error in the measurement, and the evaluated one has complied with all the requirements of the procedure.

The body composition was evaluated using a Tanita BC -418 ® electric bioimpedance balance with an accuracy of 0.1 kg for the recording of weight, fat mass, and lean mass. The scale was calibrated before beginning the process. Participants were normally hydrated so that it could not alter lean tissue values. The size was measured in centimeters using a Seca stadiometer.

After data verification and debugging, we proceeded to perform a descriptive analysis according to the type of variable, quantitative variables were described as mean and standard deviation or median and interquartile interval, depending on the normality or otherwise of its distribution. The Kolmogorov-Smirnov test was used to verify its normal distribution and the eventual need for transformations or groupings. A prediction formula was developed using multiple linear regression in two models, the first with the variables age, sex, BMI and lean mass and the second only with the use of lean mass. The accuracy and concordance of the prediction formula developed by the authors were verified and compared in these terms with the formulas of Harris & Benedict (19), Mifflin (20), Owen (22.23), Institute of Medicine (24), Estimation Fast (25) and Cunninghan (16). The Student t or Mann-Whitney U tests were used to analyze the differences of the variables according to sex. The agreement between the indirect calorimetry and the predictive models was evaluated by the Bland-Altman method and the accuracy by the percentage of values +/-10% of the value measured by IC (18). The statistical significance was reached with $p < 0.05$.

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For the models developed, the formulas that met the following criteria were selected: (i) an $r \geq 0.7$ and (ii) no linear trend in the Bland-Altman analysis method (18).

Results

Participants were 38 individuals aged between 20 to 45 years, 24 (5.5) median, the Body Mass Index (BMI) with a maximum of 34.5 and a minimum of 17.9, 24.5 (3.7), average, muscle mass maximum value was 68.7 and minimum 34.2 with 46.8 (9.5) mean. In Table 1. Mean, standard deviation or median and interquartile range are reported for each variable used in this study according to sex, as well as the p-value for the average or median difference test, the only significant difference was found in the averages of muscle mass that were higher in men so this variable was included in the prediction model.

Table 1. General characteristics

	Total (n=38)	Male (n=15)	Female (n= 23)	P
Age (years)*	24 (5.5)	27.33 (6.13)	24.9(4.54)	0,202
IMC (kg/m2)	24.5 (3.78)	26 (3.85)	24 (3.63)	0,150
Muscle mass kg	46.8 (14.3)	56 (7.98)	41 (3.82)	0,000

* Median and interquartile range

The prediction formula was developed from variables like age, sex, BMI, and muscle mass as predictive and GER as dependent, using a multiple linear regression model with the ENTER method, Table 2 shows the coefficients, value of r2 and significance, for variables used in the first model explored, it was found that only muscle mass was significant with the greatest contribution to the variation of r2.

Table 2. Multiple linear regression model for prediction of Rest Energy Expenditure

Model	Coeficiente B	Error st	T	Sig p
(constant)	133.279	312.217	0.427	0,672
Age	-7.250	4.355	-1.665	0,105
Sex	12.655	89.438	0.141	0,888
BMI	2.431	9.208	0.264	0,793
Muscle Mass (kg)	24.111	5.749	4.194	0,000

Model	R	R2	R2 change	Sig. F change
1 Enter	0.877	0.769	0.769	0,000

To verify the relevance or not of making a model that uses only muscle mass as the only significant variable, the multiple regression model was run again but this time as an "Enter step-wise forward" modality in which variables are included or not depending of its contribution to the variation in the r2 of the model, table 3. It was observed that the model includes only the variable Muscle mass (kg) and excludes the other variables so that the final prediction formula considers only the muscle mass.

Table 3. Summary of multiple linear regression model for prediction of resting energy expenditure in the adult population. Method enter step-wise forward.

Model	r	r2	Error est	r2 change	F change	Sig
1*	0.865	0.741	130.6	0.748	106,7	0,000
	B				T	
Constant	62.8		107.8		0.53	0,564
Masa Muscular Kg	23.3		2.257		10.33	0,000

*Predictoras: (Constante), Masa Muscular (kg), Dependiente: Gasto Energético en Reposo. Variables no incluidas en el modelo: Edad, Sexo, BMI

With this model that uses muscle mass, the caloric requirements were calculated with the prediction formula proposed by the authors according to linear regression coefficients described: GER = 62.8 + 23.3 * Muscle mass kg. To compare the accuracy and concordance with other prediction formulas developed with different populations, the following formulas were used: Harris & Benedict, Owen, Mifflin, Institute of Medicine, Rapid Estimation and Cunningham; for all the formulas, agreement was assessed according to the Bland Altman method, as well as the accuracy considered as the percentage of values between +/-10% of the values estimated by indirect calorimetry Table 4

Table 4. Equations used for the calculation of energy expenditure

Equation	Population	
	Men/women	
Authors, 2019		62.8+23.3*Muscle mass kg

Harris&Benedict, 1999	Men	66.4730 + 13.7516 x Weight (kg) + 5.0033 x Height (cm) – 6.7759 x Age (years).
	Women	6665.0955 + 9.5634 x Weight (Kg) + 1.8496 x Height (cm) – 4.6756 x Age (years)
Mifflin, 1990	Men	(10 x weight Kg) + (6.25 x height cm) – (5 x age years) + 5
	Women	(10 x weight Kg) + (6.25 x height cm) – (5 x age years) - 161
Instituto de Medicina, 2008	Men	247 –(2.637 x age years) + (4015 x height m) + (8.6 x weight Kg)
	Women	247 –(2.637 x age years) + (4015 x height m) + (8.6 x weight Kg)
Estimación Rápida, 2002	Men	16,2 x weight Kg
	Women	16,2 x weight Kg
Cunningham, 1980	Men	(MB) Kcal/day = [500 + 22.0 x muscle mass muscle mass (LBM)] LBM = [69.8 – 0.26 (weight kg) – 0.12 (Age years) x weight kg /73.2]
	Women	(MB) Kcal/day = [500 + 22.0 x muscle mass (LBM)] LBM = [79.5 – 0.24 (Weight kg) – 0.15 (Age years) x Weight kg /73.2]

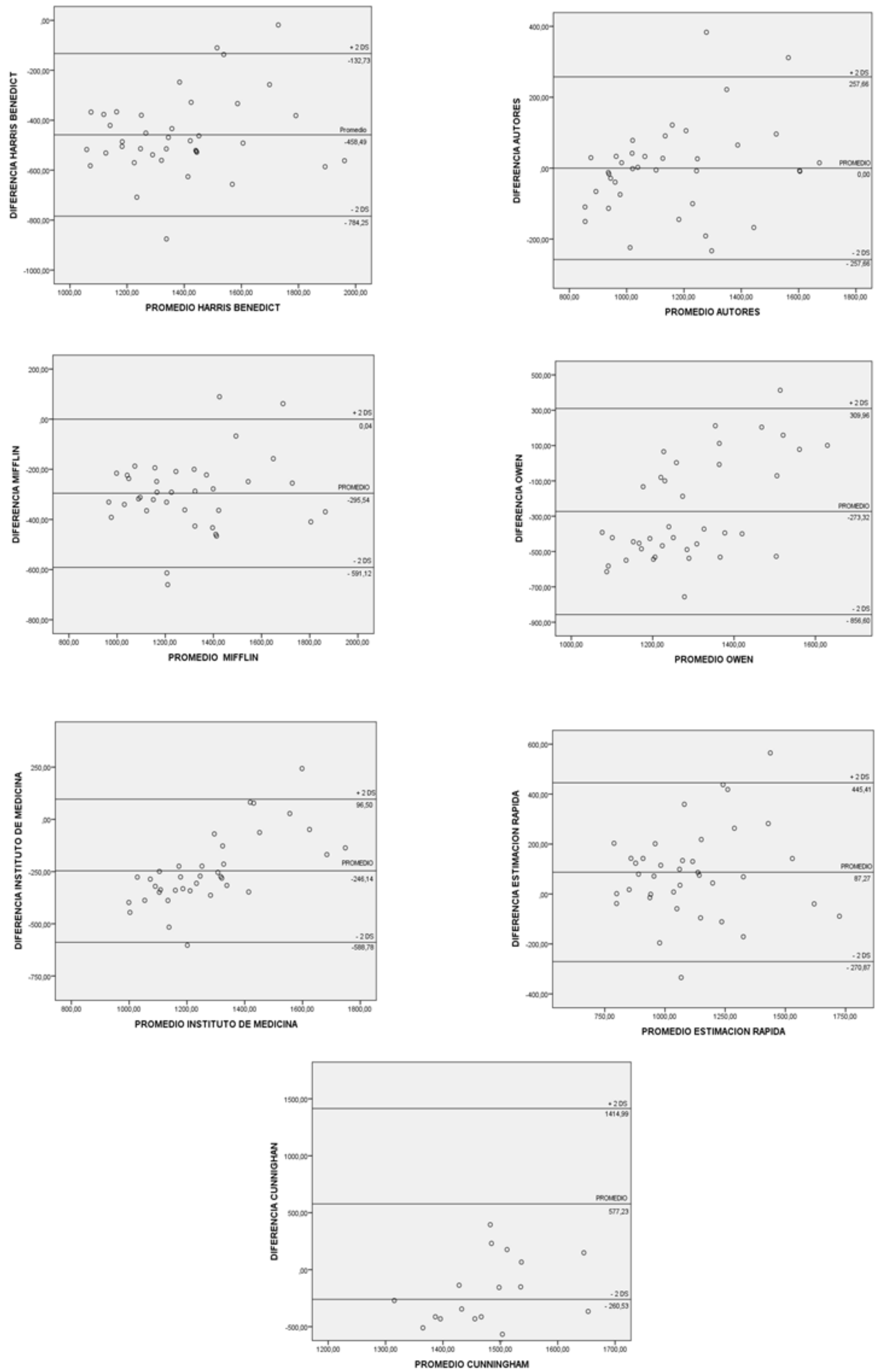
The accuracy of the prediction formulas used in the calculation of caloric requirements can be found in table 5. The best accuracy was obtained with the prediction formula developed by the authors; the percentage of accuracy of 71.1% followed by the equation of rapid estimation with 52.6% and that of least accuracy was obtained with the formula of Cunnigham 5.3%.

Table 5. Percentage of accuracy according to prediction formula

Prediction formula	% Accuracy
Autores	71.1
Harris&Benedict	7.9
Owen	26.3
Mifflin	8.1
Instituto de Medicina	18.9
Estimación Rápida	52.6
Cunnigham	5.3

For the agreement evaluation the Bland Altman method was used, it was observed that the agreement was superior for the estimation of the GER with the author's formula compared with Harris-Benedict, Mifflin, Owen, Institute of Medicine, Rapid Estimation and Cunningham. In Figure 1. The calculated values for the estimate between the estimated average values and the difference in the estimate compared with the indirect calorimetry plotted on the y-axis and the average of the measurement on the x-axis, a range of values between averages + -2 standard deviations is used and the correlation is based on the clinical significance of the range of values found, where a better agreement is observed in the equation generated by authors for the prediction of Resting Energy Requirement.

Figure 1. Bland-Altman method for concordance evaluation of prediction formula developed by the authors and other equations to estimate the Resting Energy Requirement in comparison with Indirect Calorimet



Discussión

The estimate of resting energy requirement by prediction formula developed by the authors considering muscle mass in kilograms had a concordance and accuracy significantly higher than that of Harris Benedict widely used in the clinical setting despite knowing their limitations and inaccuracy. The best accuracy and concordance observed in the formula developed by the authors is possible due to some factors, the most important that was developed with local population and because it takes into account as the main and only factor the muscle mass that is the most important determinant of the magnitude of the caloric requirement (19).

The difference in results of caloric requirements with prediction formulas and indirect calorimetry is probably due to the fact that these were developed in another type of population and any prediction formula before use should be analyzed on whether the population in the that was developed agrees or is similar to the target population in which it is desired to apply, so the formula developed by the authors does not pretend to be universal but related and applicable to a population similar to the one proposed in this study and demonstrates the need to adapt the formulas developed in different populations to those that will be applied.

A limitation in the realization of this study was the sample size, and a larger sample would give the possibility of obtaining better performance parameters of the model under study and would also considerably improve the external validity, on the other hand, a similar study should be considered with a more representative sample of the Ecuadorian population especially in the hospital environment in order to have a prediction formula that could be adequately used in hospital patients within the nutritional care process.

Conclusion

It can be concluded that the formula developed by the authors for prediction of the caloric requirement at rest in apparently healthy adults has a good concordance and accuracy with the values estimated with the indirect calorimetry method.

Conflict of interests

The authors declare no conflict of interest

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