32 - COMPARISONS BETWEEN CALORIMETRY AND THE ESTIMATING EQUATIONS OF BASAL METABOLIC RATE: A REVIEW

LEANDRO GOMIDE PEREIRA
Veiga de Almeida University - Rio de Janeiro - RJ Brazil
leandrogomide@yahoo.com.br

INTRODUCTION

Growing levels of obesity have revealed important health problems to society. According to WHO (2005), the estimate is of 250 million obese people in the world, that added to the overweight ones, reach the number of one billion people. The USA have the worst rates: about 55% of the adults are classified as above the reccomended weight, and 22% of these adults would be classified as obese (ACSM, 2001). Obesity is associated to the development of diseases as diabetes type 2, hipertension, kidney, vesicula, and lungs diseases, degenerating heart diseases, and cancer, besides a great amount of psychologic problems. (ACSM, 2001; BOUCHARD, 2003; PINHEIRO et al, 2004; WHO, 2005; ROMERO; ZANESCO, 2006). Therefore, knowing the process that lead to obesity is of great importance to control this epidemic. The Basal Metabolic Rate (BMR) would be one of these processes.

The BMR is the amount of energy that the body needs to keep its physiologic activities working properly. The quantities if energy produced during resting may be determinated by several different methods. The most famous methods of determination are: direct and indirect calorimetry and the prediction equations. Due to changes occurred in the end of the 20th century about energetic needs, new orientations about feeding were suggested. The equations gained importance and became more used to find the most precise orientation about the one's energetic needs. On the other hand, many studies (WONG et al, 1996; TVERSKAYA et al, 1998; WAHRLICK; ANJOS, 2001b; LÜHRMANN et al, 2002; ARANTES, 2003; MCDUFFIE et al, 2004; FRANKENFIELD et al, 2005) led in many different countries have begun to reveal that the equations contained some mistakes on estimating the BMR, compared to indirect calorimetry. So, the recommendations made from the equations would be providing inadequate values about one's energetic needs, criating a necessity, an understanding of comparing the equations and the calorimetry in most different populations.

The general objective of this work is reviewing the studies with the prediction equations of Basal Metabolic Rate proposed by Harris-Benedict (1919), Schofield (1985) and FAO/WHO/UNU (1985), pointing out the main differences between the estimaded values through the equations and the values measured by indirect calorimetry.

BASAL METABOLIC RATE (BMR)

The BMR is the amount of energy that the body needs to keep its physiologic activities working properly. This amount of energy, mesured in physical and mental resting, 10 to 12 hours after any kind of meal, represents about 70% of the daily energetic expenditure in human beings (BOUCHARD, 2003). This amount of energy used by our body corresponds to the high metabolic activities that some organs have, such as the liver, the heart and the brain. Besides muscle tissue, which takes a lot of this energy. Therefore, a great part of the energy we ingest is used to mantain our ordinary functions, to mantain the body balance.

The Basa Metabolic Rate can be precisely measured through a direct heat release from the body using a direct calorimetry or by the indirect method that uses a gas analyser. Both methods can be highly precise, however, these avaluations are very expensive (ARANTES, 2003).

Using these measures allowds a precise determination of one's energetic needs and so, handling a specific feeding plan is possible. Only after 1985, people have begun to make these measures to stablish the values of energetic recommendations. Before then, these recommendations were taken only from information about the population's feeding habits, healthy diets, values which normally are lower(20%) than the real need (WAHRLICH, 2001a). In this new orientation, the components of energetic expenditure should be expressed as multipliers of BMR, attempting the control of individual characteristics as body composition, age, gender. As the availability of calorimeters was very low and very expensive, the international organs (FAO/WHO/UNU, 1985) suggested the use of the equations to estimate the BMR.

FACTORS THAT INFLUENCE THE BMR

It is known that to evaluate the Basal Metabolic Rate some important variables must be controlled such as environment temperature, physical activity and feeding habits. When the measurement does not consider the control of these variables, it is said that the outcome obtained is the Resting Metabolic Rate (WAHRLICH, 2001a).

However, there are other factors that may influence the BMR, as the body composition, age, weather, tabagism, energetic restrictons, gender and medications (WAHRLICH, 2001a; ARANTES, 2003), which will be seen as follows.

Body Composition

Long before the study of the parts of the human body, relating them to the energetic expenditure, the measurement of BMR was related to body surface, teorically, animals or individuals that had bigger body surfaces were believed to have a higher metabolic component (WAHRLICH, 2001a). Only in 1919, Harris and Benedict questioned the application of this law, demonstrating that the resting metabolism was highly related not only to the area of body surface, but also to the body mass. However, is was neither constant by unit of body surface as is was previously stablished nor independent of body mass as it was believed (WAHRLICH, 2001a).

The body can be divided in four compartments, each one with the energetic expenditure related to weight. The muscle mass (12.9 kcal/kg), adipose tissue (4.49 kcal/kg), bones (2.3 kcal/kg) and residual mass (55 kcal/kg). The research that consider the body composition believe that the body weight itself could not reflect the real values of BMR, (WAHRLICH, 2001a), since there is a significant metabolic difference between the many human body tissues, as listed above.

Age

The reduction of BMR seems to be related to the changes in body composition because of aging, specificly due to the reduction of muscle mass and the increasing of fat mass (WAHRLICH, 2001a). Aging reflects abruptly on muscle mass values eather for men or women.

On the other hand, there are evidencies that even adjusting the Basal Metabolic Rate by tissue component for different ages, older people would still have a reduced BMR when compared to young ones (LUHRMANN et al, 2002). Therefore, the reduction of BMR in aging doesn't seem to be related only to a reduction of tissue, but also to a tissues' functions loss.

A possible explanation to the tissues' functions loss and therefore the reduction of BMR would lay on some changes in potassium-sodium bomb. It is estimated that a reduction in functions of the potassium-sodium bomb would result in a reduction of 3% of BMR in aged people. While the protein turnover may result in a reduction of 15% to 20% of the BMR (SOARES et al, 1994).

Wheather

Recent studies have demonstrated that the weather is not responsable for differences in the BMR, as it was believed in past. Over the years, several studies have tried to establish differences between metabolic rates in individuals came from different weather conditions in the globe (WAHRLICH, 2001a), however, in recent decades, several studies have shown there is no difference between the BMR of people who live in tropical or temperate regions (ALAM et al, 2005). The fact is that the differences found between the regions don't consider the method used to colect the BMR, and they were, in most cases, different. Therefore, the studies could not reflect exactly the answer.

Tabagism

Among smokers there is a strong idea that smoking helps fighting weight gain. According to Perkins (1989) there is a strong relation between nicotine and metabolism, since nicotine can increase as much as 6% a smoker's metabolism compared to a control group. Therefore, gaining weight could be related to the reduction of the metabolism of ex-smokers. However, is seem this is not the only cause to the gain of weight. According to Ferrara et al. (2001) aput Arantes (2003), the weight gain would be related also to an alteration in lipase lipoproteic activity in adipose tissue, responstable for the metabolism of the adipose tissue.

Physical Activity

During and after physical exercise there is an increasing in oxygen consumption which can continue for many hours, increasing energetic expenditure. It is known that during physical exercise energetic needs rise considerably, increasing oxygen consumption to levels above basal, actually, there is even a inicial oxygen deficiency (POWERS; HOWLEY, 2001). This increasing, before know as oxygen debt and now refered as Excess Postexercise Oxygen Consumption (EPOC), while in resiting, depends on the exercise intensity and lenght. Several studies have demonstrated an increasing in energy expenditure up to 24 hours after the last series of exercises (BOUCHARD, 2003).

Binzen et al (2001) have found an increase in Basal Metabolic Rate at least one hour after the weight training session of 45 minutes in high intensity. Halton et al. (1999) have shown that the reduction of the intervals between the series of weight training have significantly increased the EPOC compared to the control group, that kept longer resting intervals between the series.

Energetic Restricton

The use of extremely restrictive diet, with 800 cal/day or even less, have become comum to fight obesity. They are named as SPA or VLCD (very low calory diet). It is known that this diet may cause a reduction of the resting metabolic rate, due to tissue loss (BRYNER et al, 1999). Energetic restriction lead to a great energy concentration and cause the diet to be progressively less eficient, regarding the surprisingly low ingestions. Recent data demonstrate that caloric restriction may cause muscle mass loss and 15% reduction in Basal Metabolic Rate (FRIEDLANDER et al, 2005).

Medication and Sympathetic Nervous System

Increasing in energetic expenditure may be explaned by several pharmachologic mechanism which include higher activation in sympathetic nervous system, tireoide hormone or modification in cellular response caused by thermogenesis. Is is believed, according to Bouchard (2003), that the sympatetic nervous system (SNS) has an important role in regulation of the energetic expenditure and in food ingestion. Using microneurography to evaluate sympathetic nervous system muscle activity - AMSNS, is has been found that variabiliy in energetic expenditure in prima indians was related to the sympathetic activity variability, in other words, is has been found a lower sympathetic activity in prima indiand compared to the white people group, consequently, a higher fat accumulation in indians than in white subjects (SPRAUL et al, 1993). Recently, Zenk et al (2005) have observed that the use of the fat reductor medication Lean System 7 (3-acetil-oxo-dehydroepiandrosterone) used in the USA, when combined to exercise may increase in over 7.2% the BMR, compared to control group.

PREDICTION EQUATIONS: DESCRIPTION AND VALIDITY

The first equations were developed by Harris & Benedict in 1919 derivated from a sample made of 136 men, 103 women and 94 children originally from North America, considered healthy and obtained by indirect calorimetry. The equations were developen based on sex, age, body mass and height which were used as a control in comparison in diet or sickness situations (WAHRLICH; ANJOS, 2001a).

In 1985, Schofield compiled data of BMR avaliable, with the purpose to derivate appropriate prediction equations for international use in healthy people. Schofield analysed data from 114 studies that had a the slightest relevant data (gender, age, body mass and height). A final sample of 7173 people was obtained (4809 men and 2364 women). Most of them were north american and european youngsters (WAHRLICH, ANJOS, 2001a), from which the equations were dereved. Later, these equations were adopted by WHO with little modificadion in data basis to 11000 people (FAO/WHO/UNU, 1985) and recommended internationally, gaining popularity and being used by many health professionals.

Quadro 1.Prediction Equations of BMR

Equações	Faixa etária	Gênero	Equações
			(Kcal/dia)
Harris &	15-74	Masc	66,4730 + 13,7516(MC) + 5,0033(E) - 6,7550(I)
Benedict (1919)	15- 74	Fem	655,0955 + 9,5634(MC) + 1,8496(E) - 4,6756(I)
			(MJ/dia)1
Schofield (1985)	< 3	Masc	0,249(MC) - 0,127
		Fem	0,244(MC) - 0,130
	entre 3 e 10	Masc	0,095(MC) + 2,110
		Fem	0,085(MC) + 2,033
	entre 10 e 18	Masc	0,074(MC) + 2,74
		Fem	0,056(MC) + 2,898
	entre 18 e 30	Masc	0,063(MC) + 2,896
		Fem	0,062(MC) + 2,036
	entre 30 e 60	Masc	0,048(MC) + 3,653
		Fem	0,034(MC) + 3,538
	> ou igual 60	Masc	0,049(MC) + 2,459
		Fem	0,038(MC) + 2,755
			(MJ/dia)1
FAO/WHO/ONU	< 3	Masc	0,255(MC) - 0,226
-1985		Fem	0,255(MC) - 0,214
	entre 3 e 10	Masc	0,0949(MC) + 2,07
		Fem	0,0941(MC) + 2,09
	entre 10 e 18	Masc	0,0732(MC) + 2,72
		Fem	0,0510(MC) + 3,12
	entre 18 e 30	Masc	0,0640(MC) + 2,84
		Fem	0,0615(MC) + 2,08
	entre 30 e 60	Masc	0,0485(MC) + 3,67
		Fem	0,0364(MC) + 3,47
	> ou igual 60	Masc	0,0565(MC) + 2,04
		Fem	0,0439(MC) + 2,49

MC = massa corporal (Kg); E = estatura (cm); I = idade (anos).

1 para converter em Kcal, multiplicar o resultado por 239

FONTE: Wahrlich e Anjos (2001a)

Along the years, numerous studies have demonstrated the prediction equations of BMR inaccuracy (WONG et al, 1996; TVERSKAYA et al, 1998; WAHRLICH, ANJOS, 2001b; LÜHRMANN et al, 2002; ARANTES, 2003; MCDUFFIE et al, 2004; FRANKENFIELD et al, 2005). The problems are mainly about specificity and will be described below.

Wong et al (1996) has pointed alarming data in a review study with the main prediction equations of the rate in 8 to 17 year-old white and black children: from 10 analysed equations, 9 showed estimation errors, specially overestimation errors.The greatest alarm related to errors was found in the black children group. The FAO equation pointed a +106 123kcal/day differenc for the blacks. This data were consistently found. Mcduffie et al (2004) predicting expenditure with the equations FAO, Harris & Benedict and Schofield in 6 to 11 year-old, black and white, obese and normal-weight children pointed errors in estimation of BMR, specially overestimation ones.

A study made by Lührmann et al. (2000) with aged people (above 60 years old), with a FAO equation found a good relation to the female sex, but for men, the equation overestimated the results when compared to calorimetry. Against these founds, Frankenfield et al. (2005), in a review study with the FAO equation for elderly pointed maximum values of 17% overestimations for men and 8% underestimation and 12% overestimation for women, which means, for both sex.

As for adults, Arantes (2003) compared the Harris & Benedict and FAO equations in 18 to 39 year-old men with calorimetry and found in both situations overestimated results: 10.7% with the Harris-Benedict and 11,6% with the FAO equation.

In another analysis, now with women, Owen et al. (1986) observed an overestimation of about 13% by using FAO/WHO/UNU and Schofield equations. Wahrlich and Anjos (2001b) demonstrated there is no positive relation between the FAO, Harris & Benedict and Schofield equations in normal-weight, 20 to 40 year-old women. All equations overestimated the values measured of BMR. The equation the presented most errors was the Harris & Benedict equation (186.2 131.9 kcal, or 17.1%). Benedict himself has noticed the equation consistently provided higher values than the BMR measured in north american women and has recommended the estimation to be reduced in 5% (WAHRLICH, ANJOS, 2001a).

CONCLUSION

Comparing results between the equations and calorimetry little correlation has been shown in avaluating Basal Metabolic Rate. Generally, three important topics can summarize the lack of correlation. The first limitation is about validity. Data basis used in equation validation studies came from North America or Europe, contradicting aspects as: genetics, temperature, nutritional state and body composition. These aspects differ from one place to another, which makes it impossible to universalize them, and can influence the result of BMR (WAHRLICH, ANJOS, 2001a). The second topic is related to the world population groups in which the equations have been tested. Although some studies with elderly subjects aged 60-84y have been made, for example, they rarely focused their work on validation. Finally, there is the race matter, although there is data with different racial groups, most validation have been made in white people groups, according to Martin et al. (2004). The inaccuracy of the prediction equations may cause errors in estimation of populatons' energetic needs. However, the use of equations must not be discarded, as they are an important instrument in evaluating the individual's energetic needs. Therefore, it is recommended that the use of these equations take into account the conditions in which they will be used. It is the evaluator's responsability to choose the equation and interpretate the results, which means, the estimation errors in Basal Metabolic Rate equations.

Further studies are needed to stablish new comparisons among most different groups: diabetics and hospitalized subjects so that new equations to predict Basal Metabolic Rate can be developed considering aspects as race, physical activiy level, age and other ones.

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Endereço: Rua 4 nº 1565 ap. 401 Setor Aeroporto Goiânia-Go CEP 74075-050
leandrogomide@yahoo.com.br

COMPARISONS BETWEEN CALORIMETRY AND THE ESTIMATING EQUATIONS OF BASAL METABOLIC RATE: A REVIEW

ABSTRACT

Growing levels of obesity have revealed important health problems to society. Knowing the BMR can help the stablishment of important basis to evaluate the energy expenditure, which is related to weight gain or loss. Therefore, knowing the BMR values seems to be one of the first steps to criate a valid weight control program. The general objective of this work is reviewing the studies with the prediction equations of Basal Metabolic Rate proposed by Harris-Benedict (1919), Schofield (1985) and FAO/WHO/UNU (1985), pointing out the main differences between the estimaded values through the equations and the values measured by indirect calorimetry. The review has found several cases in which the equations to predict the BMR were inadequate. So, obtaining more information about the basal methabolism of different populations, living in different places in the world is very necessary to better evaluate and interpretate the results obtained by the equation, because it is important to understand the energetic needs of each individual to take the first step in control of health conditions such as obesity.

Key words: obesity, Basal Metabolic Rate, prediction equations

COMPARAISON ENTRE LA CALORIMETRIE ET LES ÉQUATIONS D'AVALIATION DE LA TAUX MÉTABOLIQUE DE BASE : ÉTUDE DE RÉVISION.

RÉSUMÉ

Des niveaux croissants d'obésité ont révélé des problèmes importants de santé pour la société mondiale. La connaissance de la TMB (Taux Métabolique de Base) aide dans la mise en place de bases importantes pour l'évaluation de la perte énergétique, qui est en rapport avec le gain ou la réduction de poids. Connaître les valeurs de la TMB semble donc, être un des premiers pas pour construire un programme valide de contrôle du poids. L'objectif général de cette étude est de réviser les études avec les équations de prédiction de la Taux Métabolique de Base proposées par Harris-Benedict (1919), Schofield (1985) et FAO/WHO/UNO (1985), soulignant les principales différences entre les valeurs éstimées par le biais des équations et les valeurs mésurées par la calorimetrie indirecte. La révision a montré d'inombrables cas d'inadéquations avec les équations dans la prédiction de la TMB. On recommande dans ce sens la nécessité d'obtenir plus d'informations sur le métabolisme de base dans les divers segments de la population vivant dans différentes régions du monde, tout comme le besoin de mieux évaluer et interpréter les résultats obtenus par l'équation, car il est important de connaître les besoins énergétiques de chaque individu pour faire ainsi, le premier pas dans le contrôle de maladies comme l'obésité.

Termes d'indexation: obésité, Taux Métabolique de Base, équations de prédiction.

COMPARACIÓN ENTRE CALORIMETRÍA Y LAS ECUACIONES DE ESTIMATIVA DE LA TASA METABÓLICA BASAL: ESTUDIO DE REVISIÓN

RESUMEN

Niveles crecientes de obesidad han revelado problemas importantes de salud para la sociedad mundial. El conocimiento de la TMB ayuda al establecimiento de importantes bases para la evaluación del gasto energético, que está relacionada a la ganancia o reducción de peso. Por lo tanto conocer los valores de la TMB parece ser uno de los primeros pasos para construir un programa válido de control del peso. El objetivo general de este estudio es revisar los estudios con las ecuaciones de predicción de la Tasa Metabólica Basal propuestas por Harris-Benedict (1919), Schofield (1985), y FAO/WHO/UNO (1985), apuntando las principales diferencias entre los valores estimados a través de las ecuaciones y los valores medidos a través de la calorimetría indirecta. La revisión apuntó innúmeros casos de inadecuaciones con las ecuaciones en la predicción de la TMB. Recomendando en este sentido la necesidad de obtenerse más informaciones sobre el metabolismo basal en varios segmentos poblacionales viviendo en diferentes regiones del mundo. Bien como para la necesidad de evaluar mejor e interpretar los resultados obtenidos con la ecuación, pues es importante saber las necesidades energéticas de cada individuo para así dar el primer paso hacia el control de enfermedades como la obesidad.

Términos de indexación: obesidad, Tasa Metabólica Basal, ecuaciones de predicción

COMPARAÇÃO ENTRE CALORIMETRIA E AS EQUAÇÕES DE ESTIMATIVA DA TAXA METABÓLICA BASAL: ESTUDO DE REVISÃO

RESUMO

Níveis crescentes de obesidade têm revelado problemas importantes de saúde para a sociedade mundial. O conhecimento da TMB auxilia no estabelecimento de importantes bases para a avaliação do gasto energético, que está relacionada ao ganho ou redução de peso. Portanto conhecer os valores da TMB parece ser um dos primeiros passos para construir um programa válido de controle do peso. O objetivo geral deste estudo é revisar os estudos com as equações de predição da Taxa Metabólica Basal propostas por Harris-Benedict (1919), Schofield (1985), e FAO/WHO/UNU (1985), apontando as principais diferenças entre os valores estimados através das equações e os valores medidos através da calorimetria indireta. A revisão apontou inúmeros casos de inadequações com as equações na predição da TMB. Recomendando neste sentido para a necessidade de se obter mais informações sobre o metabolismo basal nos vários segmentos populacionais vivendo em diferentes regiões do mundo. Bem como para a necessidade de melhor se avaliar e interpretar os resultados obtidos com a equação, pois é importante saber as necessidades energéticas de cada indivíduo para assim dar o primeiro passo no controle de doenças como a obesidade.

Termos de indexação: obesidade, Taxa Metabólica Basal, equações de predição.