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 recomended 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, hypertension, 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 determined 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; WAHRILICK; 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, creating 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 estimated values through the equations and the values measured by indirect calorimetry.

BASEAL 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, measured 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 maintain our ordinary functions, to maintain 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 evaluations are very expensive (ARANTES, 2003).

Using these measures allows 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 (WAHRILICH, 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 (WAHRILICH, 2001a).

However, there are other factors that may influence the BMR, as the body composition, age, weather, tabagism, energetic restrictions, gender and medications (WAHRILICH, 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 (WAHRILICH, 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 it was previously established nor independent of body mass as it was believed (WAHRILICH, 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, (WAHRILICH, 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, specially due to the reduction of muscle mass and the increasing of fat mass (WAHRILICH, 2001a). Aging reflects abruptly on muscle mass values either 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 the 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).
popularity and being used by many health professionals.

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expenditure and in food ingestion. Using microneurography to evaluate sympathetic nervous system muscle activity - AMSNS, is has
believed, according to Bouchard (2003), that the sympathetic nervous system (SNS) has an important role in regulation of the energetic
and in food ingestion. Using microneurography to evaluate sympathetic nervous system muscle activity - AMSNS, is has been
found that variability 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 indians 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
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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
developed 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 available, with the purpose to derive appropriate prediction equations for
international use in healthy people. Schofield analysed data from 114 studies that had 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
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popularity and being used by many health professionals.

**Quadro 1. Prediction Equations of BMR**

<table>
<thead>
<tr>
<th>Equations</th>
<th>F</th>
<th>MC</th>
<th>E</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harris &amp;</td>
<td>&lt; 3</td>
<td>15-74</td>
<td>Masculino</td>
<td>MC</td>
</tr>
<tr>
<td>Benedict (1919)</td>
<td>Females</td>
<td>665.095 + 9.253 (MC) + 1.509 (E) + 4.073 (F)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schofield (1985)</td>
<td>&lt; 3</td>
<td>Masculino</td>
<td>0,234(MC) + 0,277</td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>0,244(MC) + 0,303</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>entre 3 e 10</td>
<td>Masculino</td>
<td>0,09(MC) + 2,110</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>0,08(MC) + 2,033</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>entre 10 e 19</td>
<td>Masculino</td>
<td>0,07(MC) + 2,74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>0,05(MC) + 2,896</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>entre 19 e 30</td>
<td>Masculino</td>
<td>0,06(MC) + 2,055</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>0,062(MC) + 2,056</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>entre 30 e 60</td>
<td>Masculino</td>
<td>0,048(MC) + 2,659</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>0,034(MC) + 2,593</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; ou igual a 60</td>
<td>Masculino</td>
<td>0,049(MC) + 2,659</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>0,038(MC) + 2,756</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Quadro 2. Prediction Equations of BMR**

F = faixa etaria; MC = massa corporal; E = estatura; I = idade. 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; WAHLRICHE, 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 difference 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 (1996) observed an overestimation of about 13% by using FAO/WHO/UNU and Schofield equations. Wahrich 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% (WAHLRICHE, 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 (WAHLRICHE, 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 responsibility to choose the equation and interpretate the results, which means, the estimation errors in Basal Metabolic Rate equations.

Further studies are needed to stablilize 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 activity level, age and other ones.

REFERENCES
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 establishment 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 create 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 estimated 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 metabolism of different populations, living in different places in the world is very necessary to better evaluate and interpret the results obtained by the equation, because it is important to understand the energetic needs of each individual to take the first step in the control of health conditions such as obesity.

Key words: obesity, Basal Metabolic Rate, prediction equations

Comparação entre caloriometria 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 (Taux Métabolique de Base) ai da em place de bases importantes para a avaliação da perte énergétique, que 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 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 estimées par le biais des équations et les valeurs mesurées par la calorimétrie indirecte. La révision a montré d'inombrables cas d'inadéquations avec les équations dans la prediction 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 (Taux Métabolique de Base) ayuda da en place de bases importantes para la evaluación de la perte énergétique, que 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 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 innumerables casos de inadecuaciones con las ecuaciones en la predicción de la TMB. Recomendando en este sentido la necesidad de obtener 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.


Comparisons between calorimetry and the estimating equations of basal metabolic rate: A review.

Keywords: obesity, Basal Metabolic Rate, prediction equations