



## Trabajo Original

Otros

### Basal metabolic rate for high-performance female karate athletes *Tasa metabólica basal de deportistas de karate femenino de alto rendimiento*

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#### Abstract

**Introduction:** karate is a millennial martial art, currently inserted in the context of Olympic Combat Sports. However, important scientific gaps still persist in monitoring high-performance athletes, including the basal metabolism measurement of female karate athletes.

**Aim:** to contribute to understanding the applicability of equations for predicting basal metabolic rate in this population.

**Methods:** this is a cross-sectional study with a retro-analytical component, in which data were obtained from the medical records of seven athletes participating in the project "Karate São Paulo Olímpico" (São Paulo Olympic Karate) (KSP0) during their nutrition counseling, including body composition and indirect calorimetry testing, with the aim of comparing these data to basal metabolic rate prediction equations.

**Results:** only one out of the five evaluated equations did not have a significant statistical difference relative to the value obtained by open-circuit indirect calorimetry.

**Conclusion:** in case basal metabolism cannot be measured through standard methodology (calorimetry), Cunningham's prediction equation (1980) would be appropriate to obtain total energy expenditure for high-performance female karate athletes.

#### Keywords:

Basal metabolism. Calorimetry. Martial arts. Energy metabolism. Sports nutrition sciences.

#### Resumen

**Introducción:** el karate es un antiguo arte marcial que actualmente encaja en el contexto de los deportes olímpicos de combate. Sin embargo, aún quedan importantes lagunas científicas para el seguimiento de los deportistas de alto rendimiento, una de las cuales es la determinación del metabolismo basal de los deportistas de karate.

**Objetivo:** contribuir al conocimiento de la aplicabilidad de las ecuaciones predictivas para obtener la tasa metabólica basal de esta población.

**Métodos:** el estudio se caracteriza por ser transversal con un componente retroanalítico, donde se obtuvieron los datos de siete atletas de la historia clínica de cuidado nutricional del proyecto Karate São Paulo Olímpico (KSP0), referidos a la composición corporal y el examen de calorimetría indirecta, con el propósito de compararlos con las ecuaciones predictivas de la tasa metabólica basal.

**Resultados:** solo una de las cinco ecuaciones evaluadas no mostró ninguna diferencia estadísticamente significativa con respecto al valor medido mediante calorimetría indirecta de circuito abierto.

**Conclusión:** sería conveniente, si no existe la posibilidad de obtener un metabolismo basal mediante la metodología de referencia (la calorimetría), utilizar la ecuación predictiva de Cunningham (1980) con el fin de obtener el gasto energético total de los deportistas karatecas de alto rendimiento.

#### Palabras clave:

Metabolismo basal. Calorimetría. Artes marciales. Metabolismo energético. Ciencias de la nutrición y el deporte.

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## INTRODUCTION

Karate is a millennial martial art modified to become a modern sport; its potential to promote health, and physical and psychological well-being is well established (1). Currently, karate has received the classification of Olympic Combat Sport (OCS) for meeting modern Olympic competition practices, which involve aspects and concepts of contest (fair play), as well as performance measurement, scientific approach, result comparisons, and rules and standards coded and institutionalized with the aim of maximizing body performance, competitiveness, and spectacularization of body expression (2).

OCS, which include sports modalities like boxing, judo, taekwondo, and wrestling, represent 20 % to 25 % of the total medals disputed in Olympic Games (3), and this proportion should increase with the insertion of karate in the Olympic Games of 2021, in Japan. In an OCS such as karate athletes compete according to body weight divisions in order to promote sports equity in terms of body mass, and many use rapid weight loss procedures (2-10 % reduction in body mass during the week before the competition) to compete in lighter divisions and against smaller and weaker opponents. Therefore, most athletes train with a body mass greater than their competition division, and after the official weigh-in there is a rapid weight gain to compete, thus generating continuous changes in body mass (4). According to Reale et al. (5) "although some have called for the cessation of AWL altogether (6), another more pragmatic approach is to educate athletes about safer practices around AWL and recovery to reduce the potential health risks and performance decrements".

Resting metabolic rate (RMR) is defined as the minimal energy requirement to keep the vital functions of humans such as cardiovascular and respiratory system function, organic synthesis, cell membrane ion pumps, and body temperature (7). It is influenced by factors like age, sex, body composition, and physiological state (8).

The measurement of RMR is highly precise with direct and/or indirect calorimetry techniques for individuals subjected to a thermoneutral environment soon after waking up, in the postabsorptive state (10-12 h fasting), after a minimal rest of 30 min, during wakefulness, and in dorsal decubitus (9); the major difference between basal metabolic rate (BMR) and RMR is the period of resting and fasting before measurements (10). Since RMR cannot be routinely obtained through more accurate methods, such as calorimetry, the WHO proposed in 1985 the use of prediction equations to obtain this value, considering the importance of this parameter to calculate the daily energy requirements of the population at large. Those equations originated from a modification in the data bank of Schofield (11); however, studies in this area have indicated the presence of overestimated RMR values for different ethnic groups, especially for those living in the tropics (12,13). Such differences between populations were attributed to the large number of Italians in the original database (followed by other Europeans and Americans); individuals from regions of predominantly temperate climate; non-standardized calorimetry testing (pre-test fasting); differentiated body composition charac-

teristics; and narrow age range, besides the presence of diverse Caucasian individuals (14).

Although direct or indirect calorimetry is the best methodology to obtain a RMR, it has limitations such as a high cost, need of pre-test standardization, and long evaluation time. As an alternative method, mathematical prediction equations for the basal metabolic activity of individuals employ data that can be more easily obtained during nutrition counseling, including age, height, sex, body mass, and body composition (lean mass). To estimate RMRs in both men and women, the more commonly used equations are those of Harris-Benedict (15), World Health Organization (9), and Cunningham (16). Although largely used, they were not developed for female athletic populations; for example, that of Harris-Benedict had over 200 participants included in its development but only 18 individuals classified as athletes and no women (8).

The American College of Sports Medicine (17), in its Note on Nutrition and Athletic Performance, encouraged the use of specific regression equations for the athletic population but recommended that a reasonable RMR estimate could be obtained with the equations suggested by Cunningham (16) or Harris-Benedict (15) by adopting an appropriate activity factor to estimate total energy expenditure (TEE). RMR represents 60 % to 80 % of TEE for sedentary individuals but may cover only 38 % to 47 % for endurance athletes (17).

The aim of the present study was to evaluate the difference and the impact of using different RMR methodological approaches, such as open-circuit indirect calorimetry, bioimpedance, and prediction equations, on the assessment of energy expenditure in high-performance female karate athletes, since this parameter is essential to health, weight control, and performance-directed diet prescription in this population.

## MATERIAL AND METHODS

### STUDY POPULATION AND SAMPLE

Data were collected from the Integrated Health Center of a university in São Paulo, Brazil. This Center has an area of around 2.8 thousand square meters with 47 rooms for medical appointments in 10 different health areas, and 5 of these rooms are separated for nutrition counseling of physically active individuals, from sportsmen to high-performance athletes.

This study is cross-sectional with a retro-analytical component; thus, data were obtained from medical records of athletes participating in the project —Karate São Paulo Olímpico— (São Paulo Olympic Karate) (KSPO), during their nutrition counseling. As inclusion criteria, the selected medical records were of high-performance athletes participating in the KSPO project of the —Federação Paulista de Karate— (Karate Federation of São Paulo State) (FPK), who had an appointment in the area of Nutrition in Sports and Physical Exercises with the aim of improving their performance, were within the age range 19-59 years, declared in the nutritional anamnesis to be phys-

**Table I.** Data of the anthropometric evaluation of high-performance karate athletes in the project “Karate São Paulo Olímpico” (São Paulo Olympic Karate) (KSPO) of “Federação Paulista de Karate” (Karate Federation of São Paulo State) (FPK)

Variable	Mean	SD	CV	Minimal	Maximal
Age (years)	21.7	3.0	14.0	19.0	27.0
Body mass (kg)	62.1	6.0	9.7	57.0	74.5
Height (m)	1.63	0.04	2.3	1.60	1.70
BMI (kg/m <sup>2</sup> )	23.15	1.95	8.4	20.18	25.78
% Fat	23.1	2.7	11.7	20.1	26.8
FFM (kg)	47.8	5.6	11.6	43.8	59.5
FBM (kg)	14.3	1.7	11.8	12.1	16.0

SD: standard deviation; CV: coefficient of variation (standard deviation / mean) x 100; BMI: body mass index; FFM: fat-free mass; FBM: fat body mass.

ically active, and signed the appointment consent form at the Integrated Health Center.

The sample comprised seven high-performance female karate athletes participating in the modalities “kata” (moves) and “kumite” (fighting).

**VARIABLES**

Collected data included: birth date (years), body mass (kg) as obtained with a Filizola mechanical anthropometric scale (0.1 kg precision and 150 kg capacity), and height obtained with a stadiometer coupled to the aforementioned scale (1 mm precision and 2 m capacity), with athletes wearing minimal clothing and positioned in the Frankfurt plane for evaluation. Body mass index (BMI: kg/m<sup>2</sup>) was calculated and nutritional status was classified according to the WHO (18). A bioimpedance test was carried out to obtain fat percentage, fat mass, lean mass, and RMR with a Biodynamics 310E device, at 50 khz, and with athletes positioned in horizontal dorsal decubitus, keeping arms and legs apart.

Open-circuit indirect calorimetry was conducted in a nutrition counseling room with low light, temperature between 24 and 26 °C, and 70-75 % relative humidity. The RMR of athletes lying in dorsal decubitus was measured with the calorimetry device MetaCheck (Koor®, Medical Technologies, Salt Lake City, Utah, USA). RMR was calculated by the mean of values found during 20-min continuous evaluation and by prediction equations, as shown in table III.

**STATISTICAL ANALYSIS**

Results were reported as sampling summaries of central tendency and variability. To detect statistical differences between

**Table II.** Values of resting metabolic rate (RMR) obtained by indirect calorimetry, bioimpedance, and prediction equations for female karate athletes

Variable	Mean	SD	CV	Min-Max	p
<b>Resting metabolic rate measured by calorimetry</b>					
kcal/24 h	1689.0	285.5	16.9	1263.0-2146.0	-
<b>Resting metabolic rate measured by bioimpedance</b>					
kcal/24 h	1440.0	173.8	12.1	1282.0-1809.0	0.03125
<b>Resting metabolic rate measured by prediction equations</b>					
FAO/WHO/UNU, 1985 (kcal/24 h)	1409.5	88.5	6.3	1333.9-1591.2	0.03125
Harris & Benedict, 1919 (kcal/24 h)	1448.6	54.4	3.8	1409.1-1555.5	0.04688
Cunningham, 1980 (kcal/24 h)	1552.2	122.4	7.9	1463.0-1809.6	0.1563
Henry & Rees, 1991 (kcal/24 h)	1325.2	69.1	5.2	1266.2-1467.0	0.03125

**Table III.** Equations for predicting the resting metabolic rate (RMR) of high-performance female karate athletes

Reference	Equation
FAO/WHO/UNU, 1985 19-30 years	14.82 x body mass in kg + 486.6
Harris; Benedict, 1919	655.1 + (9.6 x body mass in kg) + (1.8 x height in cm) - (4.7 x age in years).
Cunningham, 1980	500 + 22 x (fat-free mass in kg)
Henry; Rees, 1991 18-30 years	[(0.048 x body mass in kg) + 2.562] x 239

BMR values for the different prediction equations a Friedman rank sum test was conducted, which established a significant difference ( $p = 9.4 \times 10^{-6}$ ) among the six methods. After that, we used calorimetric results as our reference, and investigated pairwise differences with the other methods conducting a series of paired Wilcoxon rank sum tests. Except for the Cunningham equation, all the other methods showed significant differences when compared to calorimetric results. Table II gives the corresponding  $p$ -values. We used R (19) for the statistical analyses.

## ETHICS

The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Human Research Ethics Committee at a local institution under code number CAAE: 12867319.7.0000.5492.

## RESULTS

The high-performance karate athletes of the KSPO project of FPK were, on average, 21.7 (3.0) years old, had a BMI of 23.15 (1.97) kg/m<sup>2</sup> and a fat percentage of 23.1 (2.7) %; thus, they were classified as eutrophic, according to WHO<sup>15</sup>, showing a fat percentage within the average range for physically active individuals. The complementary anthropometric profile of these athletes is shown in table I.

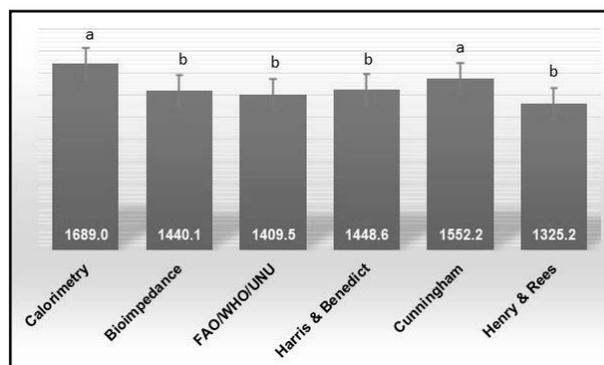
The values shown in table II were obtained by open-circuit indirect calorimetry, bioimpedance, and RMR prediction equations.

The comparisons between the results obtained by indirect calorimetry and by equations are presented in figure 1, and show that only Cunningham's equation had no significant statistical difference ( $p < 0.05$ ), and that RMR was underestimated by the different prediction equations.

## DISCUSSION

The high-performance female athletes who took part in the present study had higher body mass values and fat percentages when compared to high-performance karate athletes in the project "São Paulo Olímpico" of FPK. On average, the latter were 21.2 (4.3) years old and had a weight of 56.0 (8.8) kg, height of 160.6 (0.1) mm, BMI of 21.63 (2.58) kg/m<sup>2</sup>, and fat percentage of 18.6 (4.0) % (2). Such divergences can be attributed to differences in the body composition of these female athletes (weight category) or to the use of distinct evaluation methods, i. e., bioimpedance in the present study, compared to anthropometry.

An adequate energy balance must be kept for high-performance athletes to ensure appropriate weight and body composition during training cycles and/or the competition season; in addition, it is essential to optimize adaptations and recovery from training (20). RMR represents a significant fraction of TEE; one of the major components responsible for variation is fat-free mass,



**Figure 1.**

Results obtained by open-circuit indirect calorimetry and other methodologies (bioimpedance and prediction equations). Statistical meaning: equal letters, without statistical difference ( $p > 0.05$ ); different letters, with statistical difference ( $p < 0.05$ ).

which may represent 20-30 % of daily energy expenditure (21), suggesting a difference between females and males, even in athletic populations (20,22).

There are few studies in the setting of martial arts and in karate athletes assessing the impact of different prediction equations on RMR, and consequently on TEE. De Lorenzo and collaborators (23) developed seven general equations to calculate BMR, six of which significantly underestimated the values obtained by indirect calorimetry for water polo, judo, and karate athletes. Rossi and Tirapegui (24) investigated the impact of prediction equations on competitive university athletes and found a significant difference between BMR values as obtained with the FAO/WHO/UNU equation (9) and that proposed by Lorenzo et al (23), applicable to martial arts athletes. According to their results, there was a statistically significant difference of ~ 3 % (50.4 kcal), which had a minimal impact on the choice between equations considering applicability to male athletes.

The Harris-Benedict prediction equation (15), recommended by ACSM (17), remains one of the most commonly employed equations in nutritional prescription, although there is a significant amount of conflicting evidence regarding its validity for athletic (11,20,23,25) and female populations (26). On the other hand, Cunningham's prediction equation (16), which is based on lean mass rather than body mass, has shown good results considering its validity and applicability to athletes (21,25). Cunningham's equation has already shown better accuracy for trained athletes of both sexes (21) and recreational athletes (25). However, Jagim and collaborators (20) demonstrated that this equation led to better RMR predictions for female athletes (several modalities of athletics, swimming, soccer, and tennis) than for male athletes (soccer, athletics, and baseball).

The present study was the first one to evaluate the impact of prediction equations on BMR, compared to open-circuit indirect calorimetry for high-performance female karate athletes. Results proved that although the equation by Cunningham and collaborators underestimates BMR values, it remains as an alternative

applicable to this population for assessing TEE differently from other equations and methods such as bioimpedance. Among the limitations of the study are a small sample size, the division by weight categories, and the limited number of equations available to estimate BMR in an athletic female population, which points to further investigation and studies on this topic.

## CONCLUSION

Assessing total energy expenditure in high-performance athletes is important because energy consumption is essential to keep training, especially during intense periods, and reduced energy can lead to loss of physiological function, and increased risk of fatigue, disease and lesion, in addition to unsuccessful adaptation to prescribed training. There is evidence that, for predicting total energy consumption, RMR prediction equations may be inappropriate in athletic populations, but remain highly employed due to the limitations inherent in obtaining direct measures. This was the first study to report RMR evaluation by direct measurement for high-performance female karate athletes in comparison to the prediction equations more commonly employed in sports nutrition. Significant differences were found for the use of different equations, the most appropriate of which was that adopting the lean mass of athletes as a prediction component.

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