

# Energy balance in taekwondo athletes during pre-competition

## Authors' Contribution:

- A Study Design
- B Data Collection
- C Statistical Analysis
- D Manuscript Preparation
- E Funds Collection

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## Abstract

### Background & Study Aim:

Taekwondo athletes often rigorously limit food intake for long periods prior to competitions, rapidly reducing their total body mass to fit specific weight categories. This strategy can lead to reduced performance during training and competition and impair the health of the athletes. This study aim is the knowledge about energy balance and micronutrient intake in taekwondo athletes during the competition period.

### Material & Methods:

The study sample comprised eight taekwondo athletes ( $17.8 \pm 2.2$  years,  $60.9 \pm 12.7$  kg, and  $1.8 \pm 0.1$  m) of both sexes with competition experience at the national and international levels. The energy balance was determined by comparing the total caloric value (TCV) and the total daily energy expenditure (TDEE), which was calculated on the basis of the metabolic equivalents of task (MET). Both measurements were performed on two non-consecutive days within 2 to 3 weeks before a target competition. TCV and TDEE were compared using the paired t test ( $p < 0.05$ ).

### Results:

The results of this study indicated that the mean TCV was significantly lower than the mean TDEE ( $p < 0.001$ ), leading to a mean energy deficit of  $-1,246.2 \pm 399.5$  kcal. Carbohydrates, lipids, and proteins accounted for  $56.4 \pm 3.5\%$ ,  $24.12 \pm 2.9\%$ , and  $19.5 \pm 2.7\%$  of the energy intake, respectively, and met the energy requirements of the athletes.

### Conclusions:

These results indicated that taekwondo athletes had a negative caloric balance during the pre-competition period.

### Keywords:

energy intake · energy expenditure · martial arts athletes · MET · weight loss

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**Total caloric value** – daily energy intake (24 hour)

**Total daily energy expenditure** – daily energy expenditure in general physical activities and in sports practice

**Energy balance** – difference between total caloric value and the total daily energy expenditure

**Macronutrients** – nutrients that provide energy: carbohydrates, lipids and proteins

**Athletes' performance** – specific results in Taekwondo practice

## INTRODUCTION

Taekwondo has been recognised as an Olympic sport since 2000. This martial art requires high levels of specific and technical skills, flexibility, speed [1], quick reflexes, and strength in the upper and lower limbs [2]. For this reason, in this sport, the anaerobic energy system is essential for good performance [3]. During competition, athletes are divided into categories that are defined rigorously by limits of total body mass [4] with the aim of making the fights even by minimising the anthropometric, strength, and speed differences among fighters [5]. The inability to achieve the established weight values results in disqualification, and for this reason, restricting the total body mass is essential for taekwondo athletes during training for competition.

Accordingly, a balanced diet is important for the control of total body mass and body composition and for achieving good performance [6]. The daily energy intake of athletes ranges between 3,000 and 4,000 kcal and varies according to the athlete's profile and the competition category [6]. The energy balance is defined as the difference between the total energy intake and the total energy expenditure and directly determines the change or maintenance of body mass and composition [6,7]. An excess in the total energy intake in relation to the total energy expenditure leads to an increase in energy storage and a consequent increase in total body mass. A deficit in the total energy intake in relation to the total energy expenditure leads to energy store depletion and a consequent reduction in total body mass [7, 8]. In addition to the energy balance, adequate intake of macronutrients including carbohydrates, lipids, and proteins is important. Carbohydrates should provide 50–60% of the total energy intake, whereas lipids should provide 25–30% of the energy intake. Proteins should contribute 15–20% of the daily energy consumption, which corresponds to a daily intake of 1.2–1.7 g/kg of body mass [6]. The inadequate intake of macronutrients may affect the body composition and nutritional status, even if changes in total body mass do not occur, and can directly influence the athlete's performance [6, 9].

The daily energy intake of combat athletes during the weeks and days prior to competitions is generally low [4,10] and can reach values as low as 500 kcal/day [11]. In this respect, Fleming [4] indicated that the energy intake of taekwondo athletes from the UK exhibited significant deficits 2 weeks prior to competition, as well as imbalances in macronutrient intake. In addition, the reduction in water intake

was drastic during this period [4], and this reduction can reach extremes, i.e., the complete elimination of fluid intake for several hours immediately prior to weighing for a competition, with the goal of reducing total body mass and achieving a desired weight limit [10,11]. According to Peron et al. [12], and Fabrini et al. [13], athletes of combat sports, including taekwondo, employ various strategies to reduce body mass, including wearing special clothing and accessories that help reduce the rate of evaporation and lead to increased sweating and dehydration, in addition to fluid restriction and fasting. Such approaches, together with the drastic reduction in caloric intake and the consequent reduction in body mass, may lead to decreased performance [4,13].

According to Issurin [14], pre-competition training, which occurs a few weeks prior to the main (target) competition, aims to improve the technical and tactical skills of athletes and eliminate minor faults identified during the preparation phase. Moreover, this training attempts to enhance the mental state of athletes and adapt them to the conditions and requirements of the target competition [14]. According to Kazemi et al. [5], inappropriate strategies used to reduce the total body mass of taekwondo athletes during the pre-competition period may reduce performance during training and competition. In addition, large energy deficits and imbalances in macronutrient intake can lead to health disorders in athletes [10,15,16]. Accordingly, the energy and macronutrient intake in the pre-competition period should be monitored closely to avoid excessive imbalances and the consequent reduction in performance and/or occurrence of health disorders. This study aim is the knowledge about energy balance and micronutrient intake in taekwondo athletes during the competition period.

## MATERIAL AND METHODS

This cross-sectional and quantitative study evaluated eight Brazilian taekwondo athletes (six males and two females). The mean age, total body weight, and height were  $18.9 \pm 2.2$  years,  $60.9 \pm 12.7$  kg, and  $1.8 \pm 0.1$  m, respectively. The athletes had at least 4 years of experience with taekwondo practice, with a training frequency of six sessions a week. All of them ranked higher than the first Dan black belt degree and had participated in national and international competitions.

The energy balance was determined by comparing the total energy intake and the total energy expenditure in a 24-h period. The total caloric value (TCV)



ingested was estimated from the mean of two energy intake recordings, which were performed on two non-consecutive days. The total daily energy expenditure (TDEE) was estimated from the mean of two daily activity recordings, performed on two non-consecutive days and calculated on the basis of the metabolic equivalents of task (MET) reported by Ainsworth et al. [17] and Harrell et al. [18] according to the guidelines for research on energy expenditure in athletes [6]. To assess physical activity and food intake, the Dietpro software, version 5.1 (Viçosa, Minas Gerais, Brazil) was used. The data were collected between 2 and 3 weeks prior to the target competition, corresponding to the period of adjustment in body mass to the desired weight category.

The participants were informed of the objectives of the study and signed a consent form authorising data collection. In the case of athletes under 18 years old, their parents/guardians signed the form. All procedures used in this study were in accordance with the ethical standards for research on sports and exercise, as recommended by Harris and Atkinson [19].

#### Statistical analysis

Data normality was determined using the Shapiro-Wilk test. The data were analysed with descriptive statistics using the mean values. The mean values of TCV and TDEE were compared using Student's t test for paired samples, at a 5% significance level, and the SigmaPlot software, version 12.0 (Systat Software, San Jose, California, USA). In addition to inferential statistics, descriptive analysis was performed on the macronutrient intake proportion.

## RESULTS

All data were normally distributed. Table 1 shows the means and standard deviations of TCV, TDEE, and

the energy balance of the taekwondo athletes. The mean TCV was significantly smaller than the mean TDEE ( $p < 0.001$ ), which suggests a negative caloric balance. All athletes had a negative caloric balance.

**Table 1.** TCV, TDEE, and the energy balance of taekwondo athletes

TCV (kcal)	TDEE (kcal)	Energy balance (kcal)
$1587.9 \pm 348.5$	$2772.1 \pm 354.4^*$	$-1246.2 \pm 399.5$

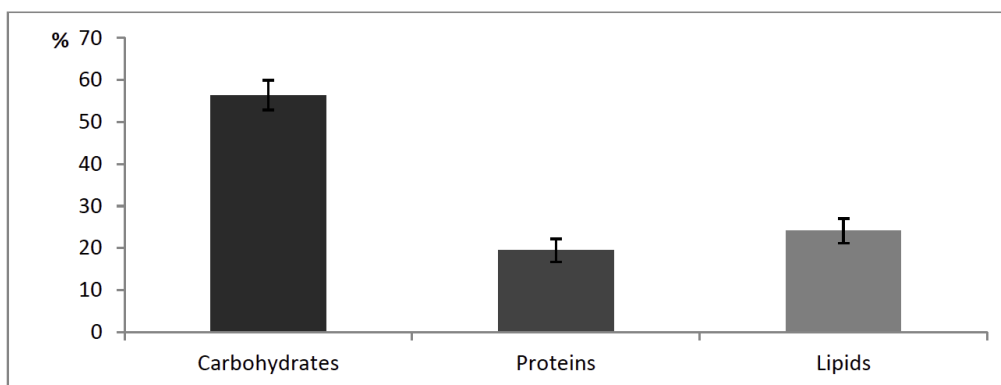
\* Significantly different compared to the mean TCV

Carbohydrates accounted for  $56.4 \pm 3.5\%$  of the energy intake; proteins and lipids accounted for  $19.5 \pm 2.7\%$  and  $24.12 \pm 2.9\%$  of the intake, respectively (Figure 1). The daily protein intake was  $1.28 \pm 0.23$  g/kg.

## DISCUSSION

The results indicated that their diet had significant energy deficits, which might decrease the energy reserves and total body mass. Considering the energy intake in the adipose tissue, where 1 kg of body fat corresponds to 7,700 kcal [20], the mean energy deficit observed may lead to a reduction of approximately 4.9 kg of body weight per month. In addition, frequent and rapid reductions in total body mass can make subsequent reductions in mass progressively more difficult to achieve, thereby requiring increased restrictions on the energy intake [11,12]. These restrictions can negatively affect performance during training and competition [4,5,11-13].

These results were similar to the results reported by Fleming [4], who assessed the dietary intake of taekwondo athletes from the UK during the 2 weeks prior to competition. These athletes had a mean daily energy deficit of 793 kcal, which led to a mean



**Figure 1.** Percentages of macronutrient intake of taekwondo athletes.

reduction of 1.2% in total body mass during the corresponding period. The author suggests that such deficits can undermine performance in both the short and long terms. However, the direct effects of the energy deficits on the athletes' performance during training and competition were not investigated in that study or in the present study. To the best of our knowledge, no other studies have investigated the nutritional status or the effects of the negative energy balance on the performance of taekwondo athletes during training and competition. These gaps in the research on energy intake and performance warrant future investigations on this important topic.

We observed that the percentage macronutrient intake was balanced according to the recommendations for athletes [6], for whom carbohydrates should provide 50–60% of the energy intake, whereas lipids and proteins should provide 25–30% and 15–20% of the energy intake, respectively. The mean protein intake in relation to total body mass followed the established recommendations. These results disagree with the findings of Fleming [4], who reported a carbohydrate intake of  $44.4 \pm 5.4\%$  and a lipid intake of  $35.4 \pm 5.4\%$ . However, our results agreed with Fleming's regarding the protein intake ( $19.5 \pm 4.8\%$ ). The differences observed most likely originate from different eating habits among the study participants. Importantly, in addition to the relative energy balance, the absolute amounts of ingested macronutrients should be monitored [6]. In this study, the relative intake of carbohydrates and lipids was adequate. Nonetheless, because the energy intake was deficient, the absolute amounts of these nutrients necessary for optimal performance were not ingested. Importantly, the intake of micronutrients, vitamins, and minerals should be adequate to meet the metabolic requirements of athletes [9]. However, this study did not investigate the micronutrient intake, and future studies on this topic should be conducted.

During taekwondo fights, the lactic anaerobic metabolism may be an important determinant for success [3], as optimal performance in this sport requires a high level of specific and technical skills, flexibility, dynamic strength, speed [1], power, and quick reflexes [2]. However, significant increases in the blood lactate concentration in athletes after a fight [3], and particularly after successive fights during a competition [2], result in increased muscle glycogen utilisation. For this reason, food intake deficits, primarily of carbohydrates, can compromise the recovery of glycogen stores and undermine performance.

Nutritional imbalances are not only responsible for performance failures during training and competition but can also lead to health disorders in athletes [10]. Perón et al. [12] argues that rapid reduction in body mass during the competition period affects performance and increases the risk of sudden death. Other adverse health effects associated with rapid reduction in body mass in combat athletes include decreased immune resistance [15], reduced blood and plasma volumes [16], decreased concentrations of anabolic hormones, decreased glomerular filtration rate, and increased electrolyte loss [5]. Generally, the athletes follow the recommendations of the technical staff to achieve a rapid reduction in total body mass [5, 12]. Panza et al. [9] noted that many other studies reinforce the need for nutritional intervention and rehabilitation in different groups of athletes. These interventions should be performed by sports nutritionists according to the specific requirements of the sport category and the athlete profile. Such intervention would ensure that the body mass categories established in taekwondo competitions are met appropriately, effectively, and safely.

Kazemi et al. [10] and Peron et al. [5] report that athletes of taekwondo and other combat sports use various strategies to drastically reduce body mass concomitantly with the reduction in food intake. According to these authors, during the weeks that precede a competition, athletes often use dehydration techniques, including the restriction of fluid intake, prolonged exposure to warm and humid environments (e.g., sauna), training in warm environments, the use of diuretics, fasting, and even the use of clothes made of plastic and/or rubber. Such strategies act in synergy with the caloric deficit generated by food restriction, and in combination they can impair the health [10] and performance during training and competition [4,5,11–13].

## CONCLUSIONS

During the pre-competition period, taekwondo athletes had a negative caloric balance. The proportions of macronutrient intake were adequate; however, the absolute values of carbohydrate and lipid intake were not achieved, as these athletes had a negative energy deficit. Such deficits can lead to reduced body mass and compromise performance during training and competition.

## HIGHLIGHTS

The energy balance of Brazilian taekwondo athletes was negative during the pre-competition training, which



can impair their performance during training and during the target competition. This study did not directly assess the athletes' performance during the period of investigation and reinforces the need to further investigate the effects of the negative caloric balance in the performance of taekwondo athletes. Furthermore, the proportions of macronutrient intake were adequate for the study participants. However, considering the significant deficit in energy intake, the ingestion of carbohydrates and lipids in absolute terms was inadequate with respect to the recommended amounts for athletes. The micronutrient intake was not investigated in the present study and should be elucidated.

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## COMPETING INTERESTS

The authors declare that they have no competing interests.

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