ORIGINAL ARTICLE

Nutritional strategies to reach the weight category in judo and karate athletes

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: Judo and karate are combat sports disciplines in which individuals compete in weight categories. Usually, the athletes are at the maximum weight permitted in their category. This is ideally reached by increasing muscle mass. The objective of this work is recommendation how to reach the adequate weight in the corresponding category by using a novel nutritional strategy.

Material & Methods: The study performed with judo athletes (n = 11, male 6; female 5) consisted in the follow up of the same group of individuals during 2 consecutive periods of time. For the first 4 months, the volunteers followed a free diet, while during the following 2-month period the same participants underwent a supervised diet program. The study performed with karate athletes (n = 14) consisted in comparing 2 groups (each 7 athletes): one following a free diet and the other following a diet under supervision by our laboratory. Three important aspects of the dietary intervention were considered: meal distribution during the day, diet composition in macronutrients and moment for application of calorie restriction for weight loss.

Results: When diet was controlled, individuals significantly decreased their body weight. This decrease was mainly due to a decrease in body fat mass. On the other hand, body muscle mass and ectomorphia increased significantly.

Conclusion: The recommended diet intervention performed in judo and karate athletes allow a weight reduction by decreasing the fat component and increasing muscle mass.

Keywords: fat mass, muscle mass, somatotype, weight control

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Anthropometry – measurement of body composition, including muscle, fat, bone and residual (visceral) mass

Eating disorder – a disturbance in eating that jeopardizes a person's physical and psychological health and performance

Food diary – document that records times and places of meals, types and amounts of foods eaten, descriptions of personal feelings when eating. The diary should also record physical activities, type, intensity, duration and feelings

Kihon – basic techniques of karate

Nutrition – science of food, nutrients and substances present in foods, their action, interaction and balance in relation with health and disease

Overweight – body weight over ideal levels that causes adverse health effects, or a negative performance in sports

Introduction

Judo and karate are sport disciplines in which individuals compete in weight categories. Both disciplines are of mixed resistance with predominance on anaerobic metabolism. Competitors reach effort peaks or sustained efforts during very short periods of time, with incomplete recovery during the contest. From a metabolic point of view, energy supply derives mainly from muscle glycogen breakdown [1]. Long training sessions use to mobilize body fat, however, close to competition training sessions have a high anaerobic and explosive component where fat is not easily mobilized. In addition, it is during this period when the competitor is concerned about reaching a correct weight.

The usual strategy consists in competing within the maximal weight allowed in a specific category. Ideally this must be reached by increasing muscle mass which is the key component in the explosive actions performed during the competition.

From a nutritional point of view, it is obvious to state that weight reduction must be performed from the body fat component [2]. Several studies in judo positively correlate excess body fat content with low sport results, technical skills and yield in energy supply [3, 4]. Fat can be mobilized, but takes time and is more efficient if the individual performs aerobic training routines, which are not usual in judo and karate training sessions close to contests [5]. In these sport disciplines, the competitor usually performs weight reduction strategies few days before competition (7-10 days before). The strategies generally used by the competitors include light to severe food restriction, liquid intake restriction, exacerbated physical activity to increase transpiration, wear anti-transpirant clothes, vomit induction and the use of laxative and diuretic agents (today these are considered as doping agents) [6-8]. However, all these strategies affect performance since glycogen deposits and hydroelectrolitic balance are severely affected. In particular, hydric reductions are accompanied by 30% reduction of energy [9]. This impairs maximal muscle power, muscular resistance as well as aerobic and anaerobic performance, reaching a premature fatigue [10-13].

The objective of this work is recommendation how to reach the adequate weight in the corresponding category by using a novel nutritional strategy.

Materials and methods

Subjects

Selection criteria included: to be considered a usual competitor, black belt, to not present any chronic disorder and non-smoker. Exclusion criteria included: to undergo muscle lesions during the protocol or to interrupt judo practice during the study period.

The study performed with judo athletes (n = 11, 6 male and 5 female) volunteers at the national and international level were selected from a training club located in Alicante (Spain inclusion and exclusion criteria were the same as stated in the judo protocol)

An intergroup study was performed for the karate protocol. Fourteen male volunteers (n = 14, consisted in comparing 2 groups: each 7 athletes), practitioners of *kumite* (combat) at the national and international level were selected from training clubs located in Elche (Spain). Inclusion and exclusion criteria were the same as stated in the judo protocol.

Experimental protocol

An intragroup study was performed for the judo protocol. The study performed with judo competitors consisted in the follow-up of the same group of individuals during 2 consecutive periods of time. During the first 4-month period, volunteers followed a free diet (JF-period). For the next two months, the same participants followed a designed diet under supervision (JD-period). This protocol was applied to 2 groups: male and female competitors (n = 6 and 5, respectively). The training program followed was the same than in karate (5 evenings/week), but included an additional training session in the morning: 3 alternative days/week of 1h/session.

The study performed with karate competitors consisted in comparing 2 groups: one following a free diet (KF-group) and the other following a diet under supervision by our laboratory (KD-group). To this end, participants were randomly and double-blindly distributed into two groups of 7 individuals each. All participants followed the same training program, consisting in exercise sessions performed in the evenings 5 days/week for a total of 7 months: technical training (*kihon* and *kata*) for 2 hours each a week, and combat training or *kumite* (6 h/week). Resting was performed 2 days/week.

Volunteers were informed of the objective and demands of the study and gave their written consent to participate. The protocol was in accordance with local legal requirements and the Helsinki Declaration

Table 1. Anthropometric characteristics of individuals participating in the study

Indicator (units)	Judo male (n = 6)	Judo female (n = 5)	Karate F-group (n = 7)	Karate D-group (n = 7)
Age (years)	22.0 ±1.7	21.0 ±2.8	20.6 ±3.0	22.0 ±4.8
Weight (kg)	77.5 ±17.5	62.6 ±9.7	69.6 ±6.9	76.1 ±12.8
Height (m)	1.75 ±0.1	1.64 ±0.1	1.75 ±0.1	1.75 ±0.1
Fat mass (%)	15.0 ±10.4	18.4 ±5.9	14.3 ±7.4	19.9 ±9.5
Muscle mass (%)	48.4 ±6.4	39.4 ±3.6	47.2 ±5.5	43.2 ±5.4

for research on human beings, and approved by the Ethical Committee of University Miguel Hernandez.

Age and anthropometric indicators of the volunteers at the beginning of the study are shown in Table 1. Anthropometry was performed every 15 days, as according to ISAK (International Society for Advancement of Kinanthropometry) recommendations [14]. Body fat mass was calculated using Siri's equation from the body density values obtained according to Withers [15, 16]. Bone mass was calculated from Rocha's equation and muscle mass from Lee's equation [17, 18]. The obtained values served to calculate the somatotype [14].

Caloric expenditure was theoretically estimated and divided into 3 components: resting metabolic rate, thermic effect of feeding and physical activity expenditure. Resting metabolism was calculated according to Harris-Benedict equation that takes in account for each gender, the weight in kg, height in cm and the age in years [19].

Corrected body weight was taken in account for calculations, considering the ideal weight as the superior limit of each weight category in the corresponding disciplines. The thermal effect of food was estimated as the 8.5% of the sum of resting metabolic rate plus physical activity expenditure. The physical activity expenditure was estimated from published tables [20].

The total daily energy expenditure was calculated for each hour and represented by histograms indicating the estimated values for each component (Figures 1A and 2A – examples of total daily energy expenditure for a karate practitioner with a training session in the evening; Figure 3A – example of total daily energy expenditure for a judo practitioner with a training session in the evening; Figure 3B – example of total daily energy expenditure for a judo practitioner with a training session in the evening and a second training session in the evening).

Diets were analysed and designed using Dietsource software (Novartis, Barcelona, Spain). In the corresponding cases (KD-group and JD-period), diets were adapted accordingly to each particular subject. Diets were adjusted to strength exercises with explosive actions, including 1.6-2.0 g of protein/kg of body weight, 1 g of fat/kg of body weight and the remaining kcal was completed with carbohydrates as the main macronutrient, corresponding to 55-60% of total kcal (Table 2). Daily energy intakes were adapted according to activity and frequency taking in account training and resting days. The free diets followed by the KF-group or performed during the JF-period were analysed from daily records provided by participants (Table 2). The record included the type of food, quantity and moment of the day for consumption. Participants were met 2 days a week in order to supervise diet and training program accomplishment.

Three important aspects were considered in the dietary intervention: meal distribution during the day, diet composition in macronutrients and moment for application of calorie restriction for weight loss. These aspects were considered and compared to the free diet reported by the individuals at the beginning of the study.

Statistical analysis

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS, v. 20.0 for Windows). The results were expressed as means

Table 2. Macronutrient composition of free (KF) and designed diets

Macronutrient (g)	KF-group (n = 14)	Judo (men) (n = 6)	Judo (women) (n = 5)	Designed diet
g proteins/kg	2.0± 0.3	2.8± 0.4	2.0 ±0.3	1.6–2.0 ±0.3
g lipids/kg	2.0± 1.0	1.8± 0.7	2.1 ±0.5	1.0 ±0.1
g carbohydrates/kg	5.6± 0.8	3.9± 0.6	4.9 ±0.6	5.0-7.0 ±1.4

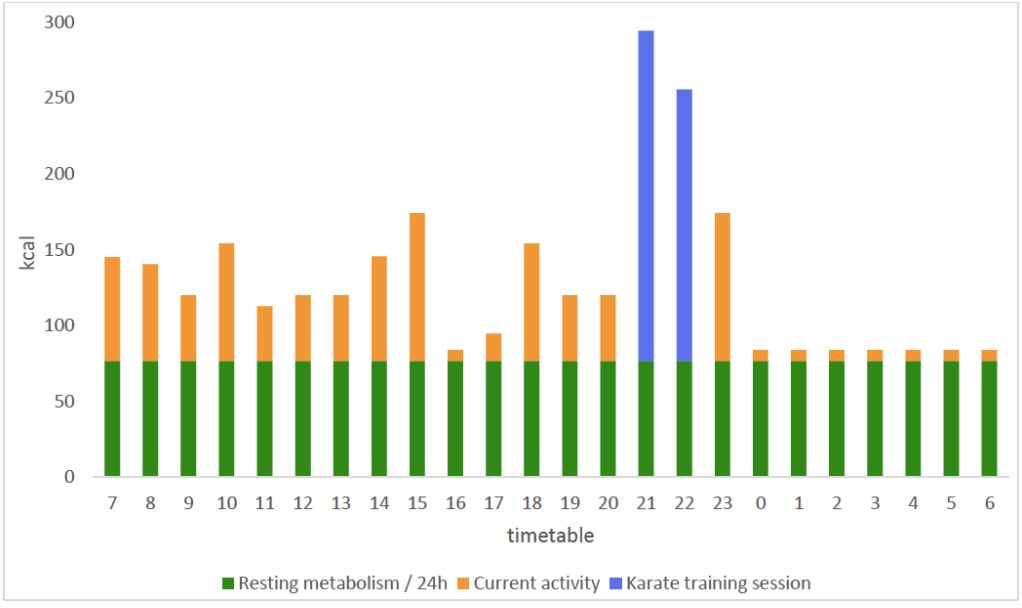

Figure 1A. Energy expenditure distribution in a karate individual (KF-group) following one evening training session (x-axis). The individual was 19 years old, height1.79 m, weight at the beginning of the study: 74.7 kg, weight at the end of the study: 76.7 kg, % of fat mass at the beginning of the study: 11.7%, % of fat mass at the end of the study: 11%, % of muscle mass at the beginning of the study: 48%, % of muscle mass at the end of the study: 48.2% and total energy expenditure 3200 kcal.

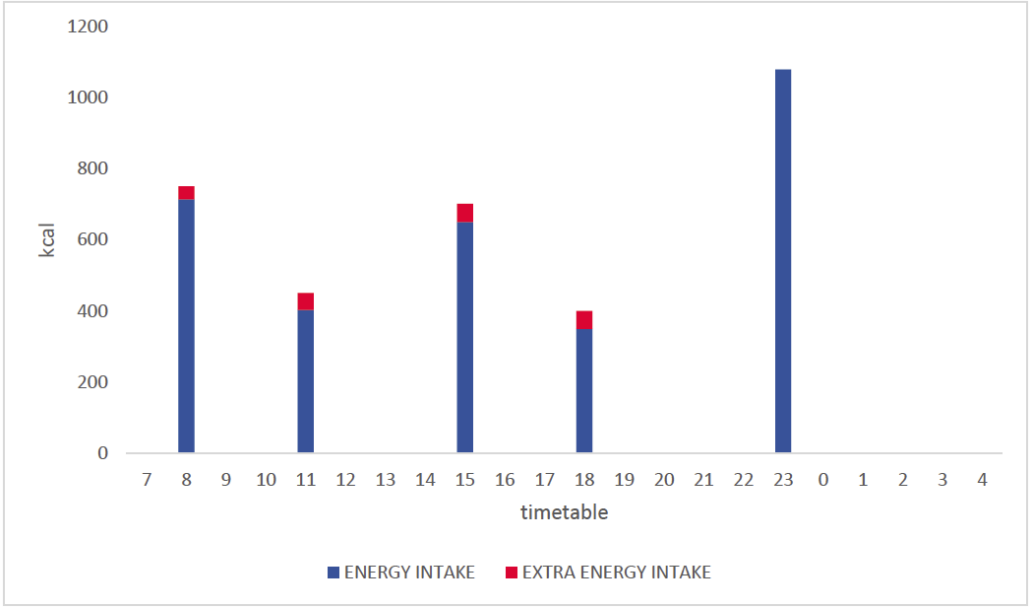

Figure 1B. Meal distribution in a karate individual of the KF-group (x-axis: training session). The extra energy intake is indicated in black. Total calorie intake: 3380 kcal

± standard error of the mean (mean ± sem). One-sample K-S test (Kolmogorov-Smirnov test) was performed in order to assess if each variable fits a normal distribution. Data obtained from the karate protocol were analyzed according to non-parametric Mann-Whitney test for independent samples, comparing the inter-group variation for KF-group vs KD-group. Data obtained from the judo protocol were analyzed according to a T-test for related samples, comparing the intra-group variation in the JF-period vs JD-period. Statistical significance was set at $p<0.05$.

Since participants were competing in different weight categories, the data corresponding to body

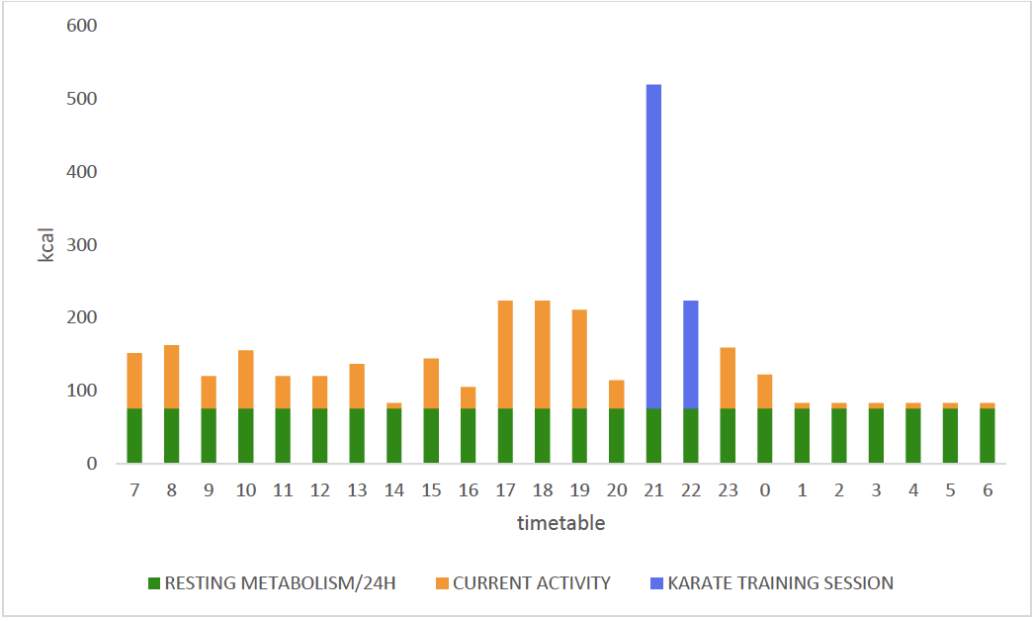

Figure 2A. Energy expenditure distribution in a karate individual (KD-group) following one evening training session (x-axis). The individual was 28 years old, height 1.84 m, weight at the beginning of the study: 78.7 kg, weight at the end of the study: 75.6 kg, % of fat mass at the beginning of the study: 8.7%, % of fat mass at the end of the study: 6.5%, % of muscle mass at the beginning of the study: 48.8%, % of muscle mass at the end of the study: 50.9% and total energy expenditure 3600 kcal

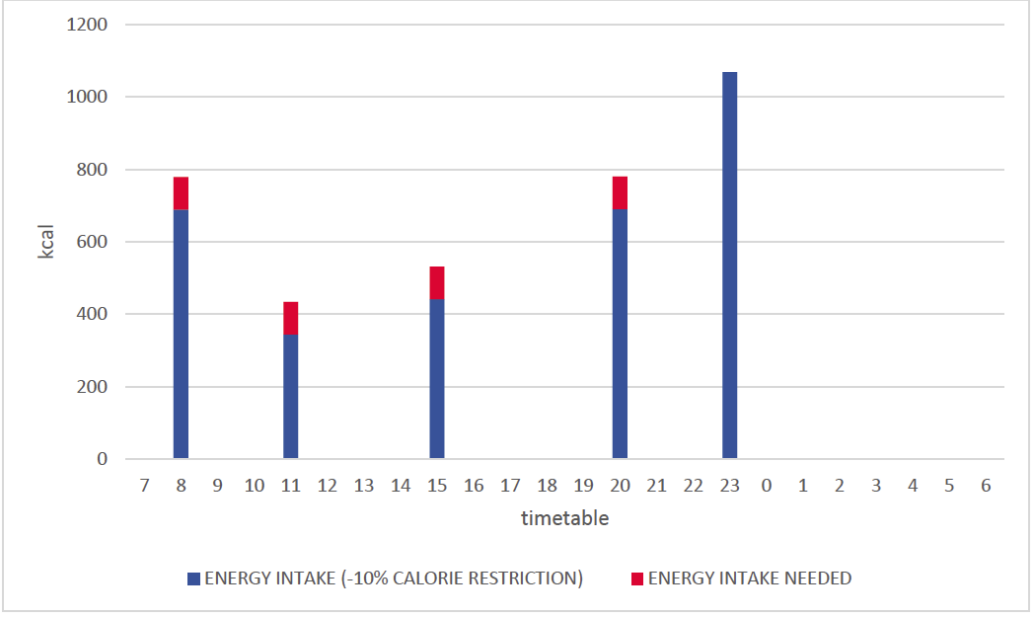

Figure 2B. Meal distribution in a karate individual of the KD-group. Modest calorie restriction (5-10%) is indicated in grey in the meals far from the evening training session (x-axis). Total calorie intake: 3250 kcal.

compartments were represented as percentages. The percentage of body fat mass at the beginning of the study ($\%F_0$) was compared with the percentage of body fat mass at the end of the study ($\%F_t$). The difference between both values ($\Delta\%F = \%F_t - \%F_0$) indicated the variation in fat component of each volunteer during the study. The same rational can be used for changes in the body muscle mass ($\Delta\%M = \%M_t - \%M_0$), being $\%M_0$ the percentage of body muscle mass at the beginning of the study and $\%M_t$ the percentage of body muscle mass at the end of the study. The changes in body weight expressed in kg were calculated by

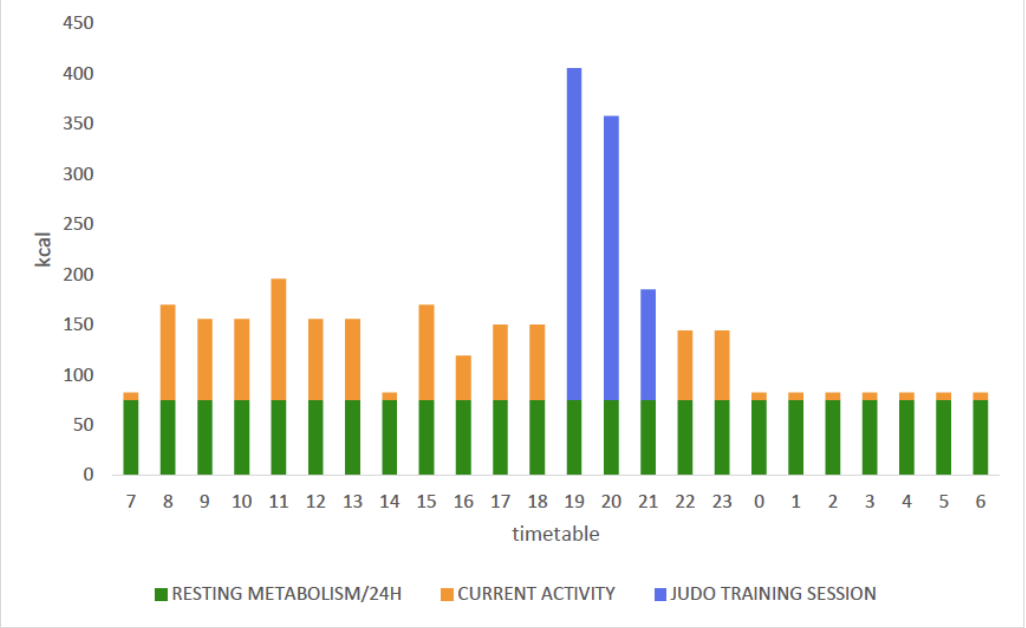

Figure 3A. Energy expenditure distribution in a judo individual (male) following one evening training session (x-axis). The individual was 24 years old, height 1.77 m and total energy expenditure: 3640 kcal.

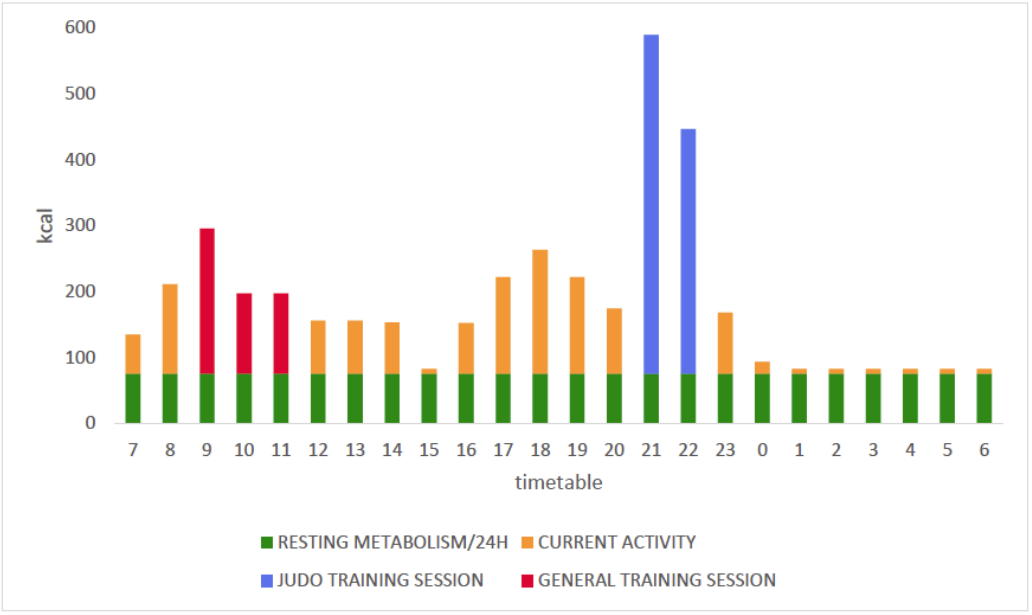

Figure 3B. Energy expenditure distribution of the same judo individual (male) following one morning and one evening training sessions (x-axis). Total energy expenditure 4260 kcal.

the difference between the weight at the beginning and end of the study ($\Delta W = W_t - W_0$). For somatotype changes, the difference at the beginning (t0) and end of the study (t): t–t0, were considered. Positive values in ΔW, Δ%F, Δ%M and somatotype are indicative of an increase in the corresponding indicator, while negative values indicate a decrease.

Results

Diet intervention

In general terms, the subjects performed 5 daily intakes: breakfast (8 h), mid-morning (11 h), lunch (15 h), evening (18 h) and dinner (23 h) (see examples in Figures 1B for KF-group and 3C for JF-period). Few individuals reported 3 meals: breakfast, lunch and dinner (not shown). Regarding meal distribution,

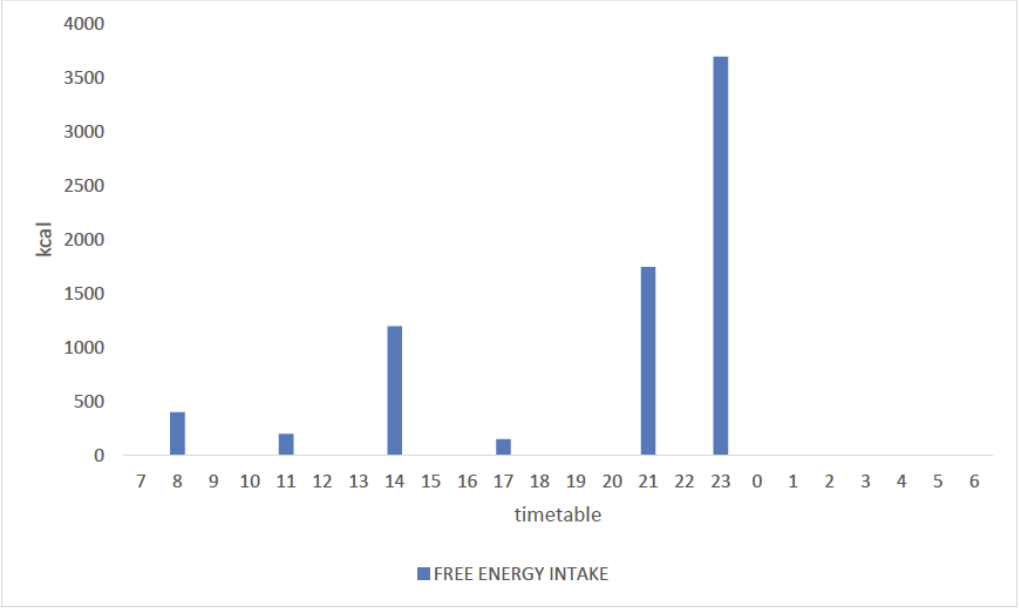

Figure 3C. Meal distribution in the same judo individual (male) during the JF-period (x-axis: training session). Weight at the beginning of the study: 74.2 kg, weight at the end of the study: 75.2 kg, % of fat mass at the beginning of the study: 8.6%, % of fat mass at the end of the study: 9.2%, % of muscle mass at the beginning of the study: 51%, % of muscle mass at the end of the study: 49.4%. Total energy expenditure 3640 kcal and total calorie intake: 3700 kcal.

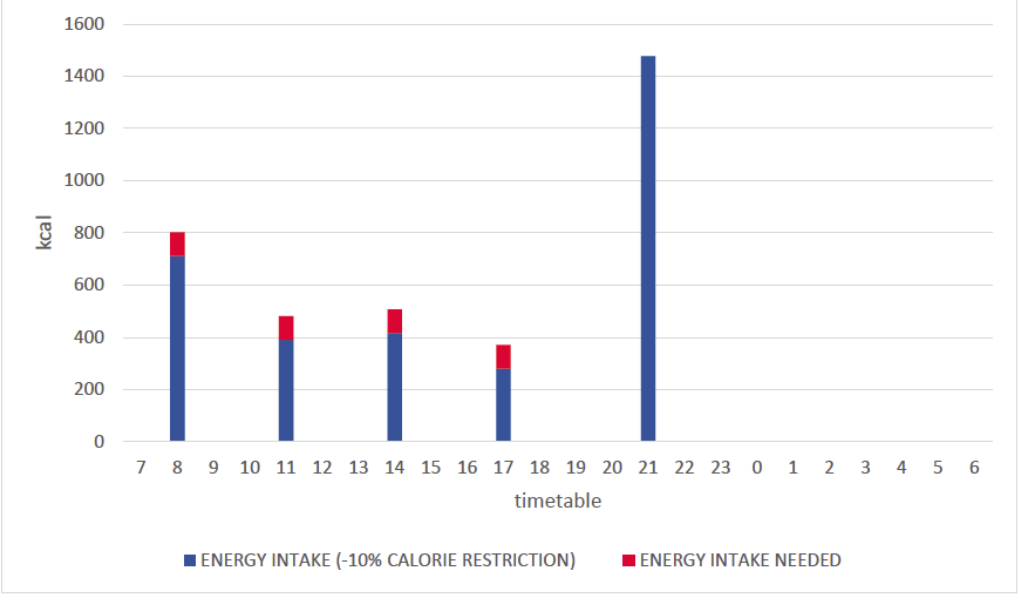

Figure 3 D. Meal distribution in the same judo individual (male) during the JD-period during a day with an evening training session (x-axis). Weight at the beginning of the study: 75.7 kg, weight at the end of the study: 74.1 kg, % of fat mass at the beginning of the study: 7.4%, % of fat mass at the end of the study: 6.7%, % of muscle mass at the beginning of the study: 52%, % of muscle mass at the end of the study: 51.8%, total energy expenditure 3640 kcal and total calorie intake: 3275 kcal.

5 meals a day seemed to be a better option. According to our records, when individuals performed 3 meals, they arrived at the main meals (lunch and dinner) with hunger, and the instauration of caloric restriction for weight management is difficult under these circumstances. In addition, our observations indicate that meals in free diets (KF-group and JF-period) are unbalanced with respect to the energy expenditure during the day. For instance, Figure 1B shows the free meal distribution (KF-group) that corresponds

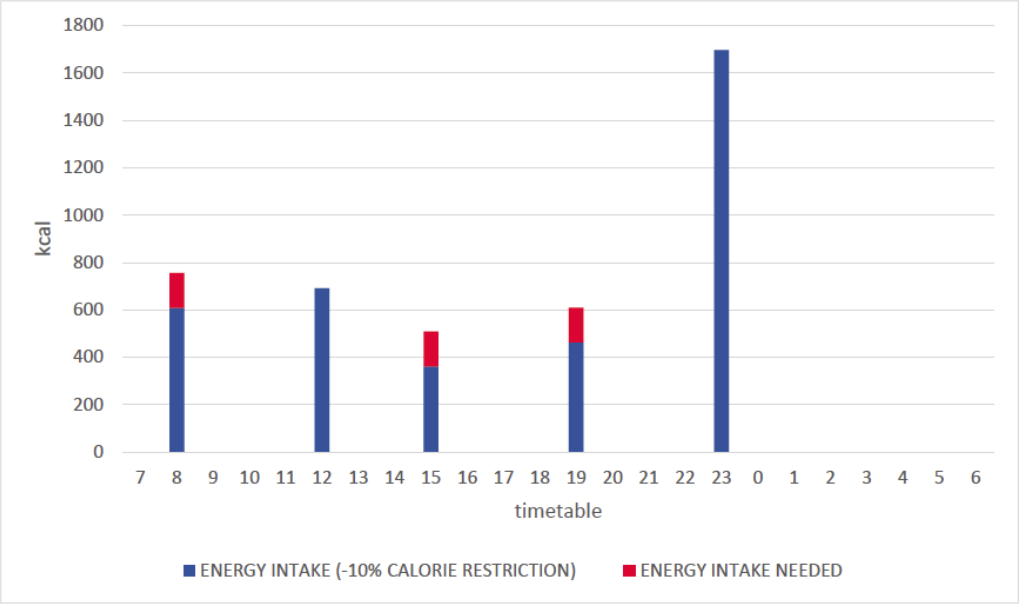

Figure 3E. Meal distribution in a judo individual (male) during the JD-period during a day with a morning and an evening training session (x-axis). Changes in weight, % of fat mass and % of muscle mass were the same that in D. Total energy expenditure 4260 kcal and total calorie intake: 3800 kcal.

to the energy expenditure of Figure 1A (one evening straining session for karate). In the example, 4 meals overpass the energy expenditure of the day and the dinner does not cover the energy spent during the training session performed. These unbalances make it difficult to apply precise weight control strategies. The contrary can be seen in Figure 2B, where the meal distribution (KD-group) corresponding to the energy expenditure of Figure 2A can be seen (one evening training session for karate). In this example, each meal covers the energy expenditure of the day. This energy distribution is distributed in a modest caloric restriction during the first 4 meals and respecting energy intake during the dinner, just after the training session of the evening. The same rational can be applied for judo practitioners when training one evening session (Figure 3A) and those with morning and evening sessions (Figure 3B). In these cases, the free diet (JF-period) distribution (Figure 3C) did not cover the energy expenditure after the morning training session. Energy balance was restored during lunch, which is very late from the morning training session. Figure 3D shows the designed meal distribution for one training session in judo (Figure 3A) and Figure 3E for two training sessions in judo (Figure 3B). Again, modest calorie restrictions are applied in meals that are not consumed after the training sessions.

The second point concerns the dietary macronutrient composition. Diets in this type of sports tend to be rich in proteins (Table 2). However, they must be taken in specific moments of the day, mainly after training sessions in order to promote muscle repair and build-up [21]. The free diets tend to be rich in proteins (Table 2), but in many cases after the training session the individuals tend to consume low calorie intakes (Figure 3C) and in some cases rich in saturated fat.

The third aspect concerns the moment to apply the caloric restriction for weight loss, if necessary. Usually, the individuals perform weight reduction strategies several days before the competition, which is highly inefficient. Rather, the strategy proposed in this work is to be applied during the whole competitor season. The meals that must respect energy expenditure are those taken after training sessions (Figure 2B for karate and Figures 3D and 3E for judo). If the individual must reduce weight, the reduction has to be applied in the meals far from the training sessions, and a small reduction (around 10% of kcal) in order to minimize hunger. For instance, in the case of judo, calorie restriction must be applied during breakfast, lunch and middle evening meals (Figures 3D and 3E) while respecting the meals just after the morning and evening training sessions (Figures 3D and 3E).

We applied these changes in the new dietary strategy and obtained the following results.

Table 3. Weight and body composition changes obtained during the different periods in judo practitioners following a free diet (JF) and those following the designed diet (JD)

Indicator (units)	JF-period	JD-period
	Men (n = 6)	
$\Delta W\ (kg) = W_t - W_0$	0.23±1.43	−3.98±2.89*
$\Delta\%M = \%M_t - \%M_0$	−0.52±1.29	2.18±2.02*
$\Delta\%F = \%F_t - \%F_0$	−0.37±1.16	−3.93±3.94*
Δectomorphia = t−t0	−0.07±0.20	0.50±0.32*
Δmesomorphia = t−t0	0.02±0.31	0.05±0.27
Δendomorphia = t−t0	−0.10±0.34	−0.90±0.88*
	Women (n = 5)	
$\Delta W\ (kg) = W_t - W_0$	0.70±1.20	−1.60±0.05*
$\Delta\%M = \%M_t - \%M_0$	1.36±1.13	2.82±2.00*
$\Delta\%F = \%F_t - \%F_0$	−2.04±1.98	−3.86±0.81*
ΔEctomorphia= t−t0	−0.14±0.23	0.28±0.13*
ΔMesomorphia= t−t0	−0.08±0.16	0.22±0.39
ΔEndomorphia= t−t0	0.42±0.64	−0.76±0.24*

(*) Statistical significance between groups p<0.05. Abbreviations used: t0 (time 0), t (final time 4 months for the JF-period and 2 months for the JD-period). Negative values in are indicative of a decrease in the corresponding indicator, meanwhile positive values indicate an increase.

Table 4. Weight and body composition changes obtained in karate practitioners following a free diet (KF) and following the designed diet (KD)

Indicator (units)	KF-group	KD-group
$\Delta W\ (kg) = W_t - W_0$	−0.39 ±1.43	−5.93 ±3.20*
$\Delta\%M = \%M_t - \%M_0$	0.11 ±1.43	4.30 ±1.35*
$\Delta\%F = \%F_t - \%F_0$	−1.10 ±1.21	−8.18 ±4.73*
ΔEctomorphia= t−t0	0.09 ±0.31	0.78 ±0.31*
ΔMesomorphia= t−t0	0.43 ±0.32	0.14 ±0.15
ΔEndomorphia= t−t0	−0.2 9 ±0.20	−1.28 ±0.74*

(*) Statistical significance between groups p<0.05. Abbreviations used: t0 (time 0), t (final time 7 months). Negative values in are indicative of a decrease in the corresponding indicator, meanwhile positive values indicate an increase.

Judo study

Similar observations were reported in the judo athletes (as those observed in karate) when they pass from a free diet to a designed diet period (Table 3). That is, decreased body weight due to lower fat mass, higher muscle mass, increased ectomorphic component, decreased endomorphic component, and the mesomorphic component was unchanged.

Karate study

This study compared 2 groups of karate athletes following a free diet (KF-group) and a designed diet (KD-group) for a weight objective in a specific category (Table 4). The KD-group significantly decreased body weight with respect to KF, which was mainly due to a decrease in body fat mass. There was no significant change in the mesomorphic component between the groups, while the ectomorphic and endomorphic components increased and decreased, respectively in the KD-group. These changes could be related with significant increases in body muscle mass.

Discussion

Diet changes during the intervention period in judo and karate athletes seem to be the major cause of the observed changes in body composition. Low calorie diet alone may help to achieve the weight objectives, but these are difficult to reach and maintain. A balanced control of energy expenditure and intake

as well as macronutrient composition, mainly by increasing intake in the meals after the training sessions and decreasing in the remaining meals, seems to be instrumental to reach correct weight and body composition indicators. Therefore, the effectiveness of diet for weight management depends on the correct application of these three components: distribution of energy intake respecting energy expenditure, macronutrient composition after the training session and moderate caloric restrictions in those meals far from the training sessions, when the individual undergoes less hunger.

The result is that this new diet strategy is focused on body fat and must be performed with enough time in order to avoid negative consequences that can produce eating disorders [22, 23], to which this population of athletes is particularly prone (manuscript in preparation). For this reason, caloric intake reduction is applied only in those meals that are far from training sessions. The complete calorie consumption is respected after training sessions, diminishing hunger and helping to recover muscle mass by profiting the metabolic window [24].

The incorrect diet planning can cause reduction in muscle mass [13, 25], eventually affecting sport performance [22]. In our intervention, muscle mass was not reduced, indicating its effectiveness. This was confirmed by the evolution of the somatotype, presenting an increase in the ectomorphic component, although more studies are necessary to predict the better somatotype for these sport disciplines.

In conclusion, a correct meal distribution (5 meals at day), respecting the post-training intakes that should be rich in proteins, paying attention to carbohydrates as well (Table 2), and applying calorie restriction (when necessary) in meals far from training sessions, will help to control the anxiety states and hunger observed when individuals follow free diets.

In the *Archives of Budo* in the last three years appeared only four publications concerning nutrition, energy cost, reduce weight in a natural way, etc. of combat sports athletes [26-29]. Due to the mission of the journal – promotion of health aspects of martial arts (and combat sports) - these issues should belong to priority. We do not charge editorial but indicate the problem to scientists, potential authors of future publications. Especially martial arts because of its large health, educational and utilitarian potential [30] deserve the recommendation as the optimal sport of life for many people [31].

Conclusions

The recommended diet intervention performed in karate and judo practitioners allow a weight reduction by decreasing the fat component and increasing muscle mass.

Highlights

Diet in combat sports by weight categories must pay attention to:

- distribution of intakes during the day: 5 better than 3 and considering the energy expenditure before the meal;
- macronutrient composition: rich in carbohydrates principally and proteins especially after training sessions;
- If calorie restriction must be applied, this should be performed in meals far from the training sessions in order to avoid hunger and incomplete store recovery underwent by the individuals.

Competing interests

Authors declare no conflicts of interest.

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