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ORIGINAL ARTICLE

Dietary Restriction in Elite Karatekas: Effect on Body Composition and Physical Performance

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ABSTRACT

Background. In weight-category sports, athletes regularly undertake weight-loss diets as competitions approach to lose weight quickly. **Objectives.** This study aimed to evaluate the effects of dietary restriction on body composition and physical performance in young elite karatekas. **Methods.** In a randomized design, 16 young karatekas volunteers (aged 20.14 ± 1.52 years) participated in this study, subdivided into two periods of 7 days each—one period of weight maintenance and one of food restriction. After anthropometric measurements, field tests aimed at assessing speed and acceleration, explosive power (counter-movement and triple standing jump), agility (T-tests), and aerobic endurance (intermittent yo-yo test 2) were performed. A 7-day food diary for each period (without and with food restriction) was used to determine nutritional intake. **Results.** A significant decrease in body mass ($p < 0.05$) was observed after the restriction period. A reduction in jumping power ($p = 0.03$), as well as a decrease in endurance capacity ($p < 0.01$), was observed. However, the agility test showed non-significant differences. **Conclusion.** Based on these results, caloric restriction for rapid weight loss impairs athletes' physical capacity and sports performance. Preventive measures against this phenomenon are necessary.

KEYWORDS: ***Karate, Physical Abilities, Tests, Diet, Rapid Weight Loss.***

INTRODUCTION

In combat sports, athletes are divided into weight categories and compete against opponents with the same body mass. For this reason, before each competition, athletes weigh themselves to identify their weight category. In Karate, as in other combat sports, weight categories ensure that competitors are equal in strength, power, and agility. In order to maintain their weight categories, athletes must maintain their body mass daily throughout the sporting season (1). However, it is difficult for athletes to maintain their desired weight categories.

For this reason, many athletes' resorts to voluntary rapid weight loss, which begins between 3 and 5 days before the competition (2). Athletes with pre-competition weight problems try to reduce their body mass by using methods such as taking diet pills, losing body fluids through sweating, limiting fluid intake, intentional vomiting, using laxatives and diuretic pills, and dehydrating by staying in the sauna for a long time. Other athletes combine weight loss techniques, including exercise with plastic (3, 4).

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However, it is well known that rapid voluntary weight loss (RWL) can have health consequences (5, 6). It is also established that rapid weight loss can lead to decreased aerobic and anaerobic performance (increased heart rate, decreased oxygen consumption, dehydration, decreased plasma volume, hydro electrolytic disorders, thermoregulation disorders, and depletion of muscle glycogen reserves) (7).

However, despite these consequences, combat sports practitioners such as karatekas do not hesitate to perform PRVP to fight in the desired categories. Combat sports practitioners around the world have reported PRVP. For example, Moore et al. (8) suggested that acute dehydration impaired wrestlers' muscle strength, work capacity, and glycolytic energy release. Another study reported a decrease in strength and endurance performance and acute fatigue following acute dehydration of 3.2% of body mass (9). In contrast, recent research has shown that rapid weight loss in judokas induced dehydration and increased heart rate responses during exercise but did not negatively affect performance on specific tasks. In Africa, Kouassi et al. (10) highlighted the strategies and consequences of this practice in elite judokas in Côte d'Ivoire. Given this literature, there are contradictory conclusions on the effects of rapid weight loss in combat sports. Also, among African karatekas, especially those from Central Africa, very little work has been done on the strategies and consequences of PRVP.

It is, therefore, crucial to study the effect of PRVP, particularly that performed by a 7-day dietary restriction, on body composition and physical performance in male karatekas preparing for a national championship. This study explores the problems associated with PRVP in karatekas during a 14-day training camp, including 7 days of dietary restriction.

MATERIALS AND METHODS

Participants. 16 volunteer elite male karatekas from the Congolese national team specializing in kumite (fighting) participated in this study. Fourteen were medalists at the 2022 African junior and senior championships in Cairo (Egypt). The sample size was estimated using G*Power software (version 3.1.9.7; Universitat Kiel, Dusseldorf, Germany) using an apriori test with an effect size of 0.25 and 0.85 statistical power using a two-tailed independent t-test. No pathological history was reported in these participants that could compromise the tested performance. All participants were informed of the aims, objectives, and conduct of the study and gave written informed consent. The study was approved by the scientific committee of the Higher Institute of Physical Education and Sport (ISEPS), of Marien Ngouabi University (Congo) and was conducted under the Declaration of Helsinki.

Procedure. The research was conducted during a 14-day training session, subdivided into two consecutive periods of 7 days each. The first period was maintenance (usual diet), and the second was food restriction. During the maintenance period, the Karatekas had to maintain their usual diet. However, during the dietary restriction period, the athletes followed a low-carbohydrate diet and reduced their food and water intake. In this study, which focused on the assessment of Karatekas' physical abilities, participants were asked not to engage in any other strenuous physical activity for 48 hours prior to the first data collection and during the 14 days of the survey in order not to introduce bias in the results of the selected field tests. During the intervention, data were therefore collected in two sessions (before and after), i.e., before the start of the restriction period (seven days after the start of the camp) and after the restriction period (after the seven days of restriction). Anthropometric measurements, as well as field tests, were carried out. The eating habits of the karatekas were also observed during this period. One week prior to the start of the grouping, all tests were performed by all karatekas in order to familiarize them with the selected field tests and reduce the training effect.

Height and body mass were measured to the nearest cm and 100 g, respectively, using the techniques recommended by Mac Dougall et al. (11), with a ZT-150A scale (Perlong Medical Equipment, China) and an automatic digital scale (Xiangshian, China). These measurements were taken according to standard norms and by a single experimenter.

The athletes performed two trials for each test except for the Yoyo - IRT 2, which was held in a single session. The best performance was then retained. A 2-minute break separated consecutive trials.

Flexibility. The Sideward Leg Splits Test (SdLS) was chosen to assess the flexibility of the front leg's hamstring muscles and the back leg's

adductor muscles (12). The participant stands on a smooth board and balances with both hands. His back foot is turned outwards and forms a 90° angle with the front foot. Then he slowly moves both feet apart. The trunk remains straight (i.e., aligned with a vertical line on the wall), and no hip rotation is allowed.

Acceleration and speed. To measure acceleration over 10 m (first 10 m sprint - 10 s) and maximum speed over a short distance (10 m rolling start - 10 FS), a 20 min sprint test was performed with 10 m intervals timed separately with a chronometer.

Agility. Agility was assessed using the T (TT) test to evaluate the ability to change direction, an ability of fundamental importance in martial arts (13). The course of this test consists of two straight 10-meter sections forming the shape of the letter T. It includes a sprint to the front and a run to the back. It consists of a forward sprint (10m), a lateral move to the left (5m), a lateral move to the right (10m), a lateral shuffle back to the left (5m), and a 10m backpedal to the start. The same equipment as for the previous test was used to measure the duration of the test (14).

Power. The counter-movement jump (CMJ) and the standing triple jump (STJ) were used to assess power indirectly. These tests were used to indirectly assess the explosive power of the leg extensors in the vertical and horizontal planes. These tests were selected because of their presumed validity for assessing lower limb performance in karate competitors (15, 16). These tests also allow the measurement of the explosiveness of the hip and knee extensors. The action of these muscles is essential for both karate stepping and kicking. Both of these tests are intended to provide independent indices of body size and muscle output; therefore, standardization of the recorded data is unnecessary (17, 18).

CMJ - Subjects were instructed to jump as high as possible by performing a preceding counter-movement with an arm swing. Subjects were also instructed to land approximately at the take-off point. The test was performed on a contact platform (contact plate, Globus, Codogne, Italy; accuracy ± 0.001 seconds) which records the time of flight (t). The jump height was measured from the flight time (t; in s) by applying the ballistic law: h = 1/8 t2g (g = 9.81 m/s2). High intratracheal and test-retest reliability of the CMJ has been reported (ICC > 0.9) (19, 20).

STJ - Subjects were instructed to jump as far as possible by performing a triple standing jump from a standard standing position. The distance from the starting point to heel contact was used to determine the jump distance. The accuracy of the measurement was 1 cm. Markovic (19) found high intra-trial reliability (ICC = 0.93) and factorial validity of this test (r = 0.80)

Endurance. Yo-yo Intermittent Recovery test (Yo-yo IRT2) was used to calculate $\dot{V}O_2$max (20). This test is based on an intermittent shuttle run performed over a distance of 20 m with an active recovery zone of 5 m. At the audio recording signal that serves as a guide to the test, the athlete runs the distance back and forth and then pauses for 10 s in active recovery (20). From the level reached by the athlete, the distance covered was determined and the $\dot{V}O_2$max was calculated according to the following equation:

Yo-Yo IRT2: $\dot{V}O_2$max (mL/min/kg) = IRT2 distance (m) x 0.0136 + 45.3

Assessment of nutritional intake. Each participant kept a food diary for the 14 days of the study to allow assessment of fat, protein, and carbohydrate intake. The food diary provided a detailed record of the foods and drinks consumed by the Karatekas during the survey period. These daily nutrient intake values were calculated using the Nutrisoft-Bilnut food assessment software (ver. 4, Paris, France). The dietary restriction plan (-6 MJ/D) was carried out according to the report of Giannini et al. (4).

Statistical analysis. SPSS 22.0 software (SPSS INC, Chicago, IL) was used to analyze the data. Standard descriptive statistics (mean and standard deviation) were calculated for each variable. The normality of the distributions was tested using the Kolmogorov-Smirnov test. Independent and paired sample Student's T-tests, the Wilcoxon rank test, and the Man Withney U-test were performed according to the appropriate procedure. Statistically significant differences between the two groups were tested using the two-tailed independent t-test. The significance level was set at $p < 0.05$.

RESULTS

The participants had a mean age of 20.14 ± 1.52 years, a mean body mass of 67.83 ± 5.60 kg, and a mean BMI of 23.63 ± 1.60 kg/m^2, and had been in the sport for 8 ± 3 years. These athletes were all international-level athletes.

The mean energy intake of the athletes at the beginning of the maintenance period was 12.07 ± 1.5 MJ. During the food restriction period, the average energy intake was 8.3 ± 1.3 MJ, i.e., an average reduction of 29.7%. The analysis of this energy parameter shows a significant decrease in carbohydrates (345.8 ± 73.9 g *versus* 187.8 ± 57.4 g; $p < 0.01$).

At the end of the food restriction period, the weight of the athletes decreased significantly ($p < 0.001$) by 5.1%. However, there was no significant difference in the maintenance period (Figure 1).

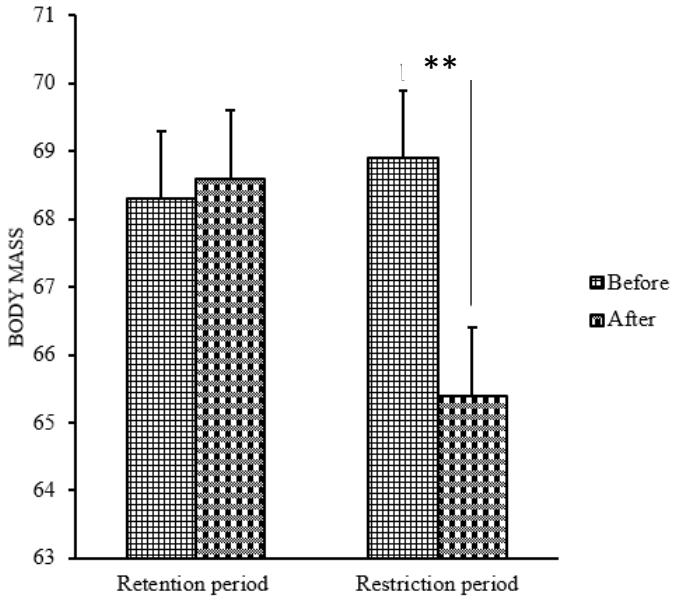

Figure 1. Changes in body mass of athletes at the beginning and end of the two periods (maintenance and restriction)

The analysis of physical parameters (Table 1) reveals that no significant changes were observed in the maintenance period (at the beginning and the end). However, during the food restriction period, a decrease in jump height at CMJ (46.8 ± 5.3 cm versus 44.3 ± 5.3 cm; $p < 0.05$), distance covered at TSD (6.86 ± 0.53 m versus 5.25 ± 0.53 m; $p < 0.01$) as well as $\dot{V}O_2$max (57.8 ± 3.46 mL/min/Kg versus 54.9 ± 3.17 mL/min/Kg; $p < 0.01$).

Table 1. Changes in athletes' physical parameters at the beginning and end of the two periods (maintenance and restriction)

Variables	Retention period (n = 16)		Restriction period (n = 16)	
	After	**Before**	**After**	**Before**
10S (s)	1.84 ± 0.03	1.83 ± 0.035	1.86 ± 0.03	1.84 ± 0.03
TT (s)	10.83 ± 0.23	10.80 ± 0.31	10.82 ± 0.30	10.83 ± 0.27
CMJ (cm)	46.7 ± 4.0	46.9 ± 5.1	46.8 ± 5.3	44.3 ± 5.3*
TSD(m)	6.82 ± 0.23	6.83 ± 0,35	6.86 ± 0.53	5.25 ± 0.53**
$\dot{V}O_2$max (mL/min/Kg)	57.8 ± 3.30	57.6 ± 3,41	57.8 ± 3.46	54.9 ± 3.17**

DISCUSSION

This study aimed to evaluate the effects of dietary restriction, used as a method of voluntary rapid weight loss (VRLW), on the performance of elite African karatekas, particularly those from Congo, in field tests aimed at assessing their physical, muscular, and energy capacity as well as their agility. The main findings of this study revealed that during the period of dietary restriction, 1) a loss of body mass of more than 5% in karatekas was observed; 2) a decrease in performance in field tests reflecting a decline in physical and muscular capacities was observed, and 3) a drop in V ̇O2max values suggesting a negative influence of dietary restriction on this parameter.

The practice of food restriction is one of the most used PRVP methods by the Congolese karatekas. With this method, they lost 5.1% of their body mass in 7 days. Dietary restriction is indeed the preferred

method for African athletes practicing PRVP. Kouassi et al. (21) had shown that the elite judokas of Cote d'Ivoire did not hesitate to resort to food and water restriction. In the present study, the participants showed a much greater reduction in body weight during the period of food restriction than during the maintenance period. The magnitude of the body weight reduction was approximately 5%. The energy intake deficit was about 6MJ/d. This decrease in energy intake could partly explain the decrease in performance observed during this study in Congolese Karatekas. It should be noted that the magnitude of the PRVP of Congolese karatekas is not different from that practiced by other practitioners of percussion combat sports. In fact, in percussion sports, weight losses are, on average, 3 to 5% (22, 23), as was observed in the present study.

The results of the present study corroborate those of Kouassi et al. (10), who reported a 6% weight reduction following a rapid voluntary weight loss after a 2-week training camp in elite judokas from Côte d'Ivoire. Similarly, some authors have reported a 10% reduction in body weight in taekwondo athletes before the competition (24). In this context, Artioli et al. (25) observed a decrease of about 4% in body weight in judokas after 5 days compared to control values. The discrepancies in weight variations observed between these studies can be explained by the different methods of rapid weight loss used by athletes. Indeed, the methods commonly used by martial artists are increased exercise, training in heated areas, progressive dieting, and water restriction (4).

The loss of 5.1% of body mass is a concern for these karatekas, as it is well known that rapid weight loss is strongly associated with dehydration of the athlete. Indeed, during rapid weight loss, the athlete loses water from his body and becomes dehydrated. When the lost water is not replaced, the risk of a drop in performance increases. Horswill et al. (26) studied the variation in strength after a period of rapid weight loss and found that a 6% reduction in body weight induced a decrease in strength in athletes. The same is true of Barley et al. (27), who reported that a rapid weight loss of 5% of body mass resulted in significant reductions in medicine ball throwing and sled pushing performance. The decline in performance after PRVP is strongly associated with reduced energy intake, as found in the present study, and with dehydration induced by a drop in water intake.

A water loss of 2% of body mass reduces physical capacity by 20% (28, 29). A greater loss of up to 5% of body weight poses very serious risks to health and performance, and a greater loss of 8-10% of body weight can have lethal consequences (30). The practice of Congolese Karatekas (PRVP of 5% of body mass in 7 days) could thus expose them to potential health risks and a decrease in both muscular and energetic performance. The decrease in energy capacities was confirmed in this study by the inflection of V ̇O2max in Congolese karatekas after PRVP. The literature corroborates the present study's finding, as rapid weight loss has also been shown to affect the endurance capacity of athletes (31-33). The work of Kouassi et al. (10), carried out with West African judokas, showed a deterioration in aerobic performance after rapid weight loss. These authors observed a 31.4% drop in $\dot{V}O_2$max following a rapid voluntary weight loss after a 2-week training camp in elite judokas from the Ivory Coast. This trend of decreasing $\dot{V}O_2$max was also observed in the present study. This decrease in aerobic capacity can be explained by the water loss induced during food restriction and insufficient energy intake. In this regard, some authors have suggested that meeting energy and nutritional needs during matches and competitions should be a priority for athletes to maintain their recovery and aerobic performance (34). Another plausible explanation for this decrease in $\dot{V}O_2$max is the weight loss recorded by the participants in group 1. Indeed, a 2% fluid loss value induces an increase in heart rate and a decrease in stroke volume, which alters cardiac output (35).

On the other hand, Fortes et al (24) reported that a two-week 10% reduction in body weight of taekwondo athletes prior to competition had no effect on their strength and athletic performance. This difference in results between the present study and that of Fortes et al. (24) could be explained by the timing of the PRVP. Indeed, the taekwondo athletes performed PRVP in a fortnight, a longer time than the Karatekas, who performed PRVP in only 7 days. The longer the loss time, the more body fat the athlete loses, so this loss does not affect performance. When the loss is rapid, however, the athlete becomes dehydrated, and performance is compromised.

Although this study explores the issues surrounding rapid voluntary weight loss, confounding factors such as training load intensity were not considered. Fluid and electrolyte losses were also not assessed for their involvement in the decline in athlete performance. It would be imperative that future work takes into account the measurement of training load and fluid and electrolyte losses.

CONCLUSION

The results of this study reveal that: First, the restriction period resulted in a statistically significant decrease in body weight. Secondly, there was a significant difference in power at the end of the diet restriction period. Thirdly, a significant decrease in endurance capacity was observed at the end of the diet restriction period. However, the agility test showed no significant difference. In view of these results, caloric restriction for rapid weight loss impairs athletes' physical capacity and sports performance. Preventive measures against this phenomenon are necessary.

APPLICABLE REMARKS

- This study is considered important information for athletes who practice voluntary rapid weight loss using dietary restriction.
- This study also allows athletes and trainers to consider the dangers of this method of voluntary weight loss.

AUTHORS' CONTRIBUTIONS

Study concept and design: Simplice Innocent Moussouami. Acquisition of data: Clive Mabika Nzoumba. Analysis and interpretation of data: Jean Paul Kouassi. Drafting the manuscript: Yvon Rock Ghislain Alongo. Critical revision of the manuscript for important intellectual content: Jean Paul Kouassi. Statistical analysis: Simplice Innocent Moussouami. Administrative, technical, and material support: Yvon Rock Ghislain Alongo. Study supervision: Issiako Bio Nigan.

CONFLICT OF INTEREST

The authors mention that there is no "Conflict of Interest" in this study.

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