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ORIGINAL ARTICLE

Effect of weight-control practices of high-level female judokas over competition period on body composition and factors of performance



Effet d'une restriction alimentaire sur la composition corporelle et les facteurs de la performance chez des judokates de haut niveau lors d'une période de compétition

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KEYWORDS

Weight-control practices;
Body composition;
Eating habits;
Judo;
Sport performance

Summary

Purpose. – This study was conducted to estimate the impact of the food practices of high-level judokas on body composition, muscle performance and food habits.

Methods. – Thirteen elite judokas were distributed in two groups: a group with weight-control practice (group D, $n=6$) and a group without it (group ND, $n=7$). Eating habits, sport performance and body composition were evaluated three times during the experiment: out (ES), pre (PRE C) and post-competitive (POST C) periods.

Results. – For the D group, we observed a decrease of body mass index, of the sum of skin folds thickness and of circumference of thigh between ES and PRE C periods, and an increase between PRE C and POST C periods. For the ND group, no difference was observed whatever the considered period. For strength tests, there is no difference between groups and between the different periods. Total energy intake and macronutrient intake of the D group decreased between ES and PRE C periods. This decrease concerned mainly fat intake. These parameters increased between PRE and POST C periods.

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MOTS CLÉS

Restriction alimentaire ;
Composition corporelle ;
Comportement alimentaire ;
Judo ;
Facteurs de performance

Conclusion. – In this study carried out on elite female judoka, changes in body composition and total energy intake had no effect on muscle performance and did not cause eating disorders.
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Résumé Objectif Cette étude a pour but d'évaluer l'effet d'une restriction alimentaire sur la composition corporelle, des facteurs de performance et le comportement alimentaire chez des judokates de haut niveau en période de compétition.

Méthodes. – Treize judokates d'élite sont divisées en 2 groupes, le groupe D ($n=6$) qui suit un régime et le groupe ND ($n=7$) qui n'en suit pas. Le comportement alimentaire, les facteurs de la performance et la composition corporelle ont été étudiés au cours de 3 périodes: hors (ES), pré (PRE C) et post (POST C) compétition.

Résultats. – Pour le groupe D, nous observons entre les périodes ES et PRE C une diminution de l'indice de masse corporelle, de la somme des plis cutanés et de la circonférence de la cuisse; et une augmentation de ces paramètres entre les périodes PRE et POST C. Pour le groupe ND, nous n'observons aucune différence quelle que soit la période considérée. Les tests de force ne montrent aucune différence intra ou inter-groupes. Les apports énergétiques totaux et en macronutriments du groupe D diminuent entre les périodes ES et PRE C. Cette diminution concerne principalement les lipides. Ces paramètres augmentent fortement entre PRE et POST C.

Conclusion. – Chez des judokates de haut niveau, les changements de composition corporelle et d'apports énergétiques causés par une restriction alimentaire n'ont pas eu d'impact sur la performance musculaire et n'ont provoqué aucun trouble du comportement alimentaire.

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1. Introduction

Judo is a weight category sport where competitions are much regulated. Indeed, the regulation of competitions in combat sports includes a classification according to body mass allowing fairer fights. Most studies conducted on sports with weight class were mainly focused on wrestlers [1]. The few studies carried out on judokas [2] showed that 90% of judokas (excluding heavy weight athletes) reduce their body weight quickly prior to competition. The rapid weight loss was usually done in 3–4 days and allowed judokas to qualify in a lighter weight division [3]. Gender was not a factor affecting the prevalence of this rapid weight loss [2]. The food restrictions practices or weight-control practices are various. They include severe restrictions of food and fluid intake, exercising in rubber or plastic suits, using saunas, taking diet pills and vomiting. In general, athletes used a combination of these severe weight-control practices [1,4]. The frequent self-selected regimen used by judokas can be explained by the eating disorders (ED). The increase of prevalence of eating disorders was observed as much in the world's sporting community as it was in the general population [5]. These disorders are characterized by attitudes, behavior and complex strategies associated with a permanent concern of weight and physical aesthetics [6]. Most of the practices of food restrictions have unhealthy consequences not only on the biological functions but also on thermal regulation, body composition, endurance and muscle strength, all this being able to impair performance [7].

The main studies conducted on eating disorders for weight category sport were American ones and took an interest in wrestlers. Some authors conducted studies about the effects of weight loss on nutrition, growth, maturation, body composition and strength in wrestlers [8] and judokas [3]. They observed, for male wrestlers, that a deficient dietary intake decreased the accrual of lean arm and thigh cross-sectional muscle area during the season and increased during the post-season. Elbow and knee strength were reduced during the season and were increased in post-season. For the judokas, male or female, the authors showed a decrease of fat mass between the period out and pre season. No effect on performance was observed when the weight loss is fast (3–4 days) whereas for a gradual weight loss, an improve of performance was observed due to a better muscle mechanical functioning [9].

Moreover, for rapid or gradual weight loss, other authors observed that a long dietary restriction can affect protein catabolism [10] or muscle glycogen [11]. Another study carried out on the difference of handgrip strength performance between judokas and non-judokas [12] showed that there was no difference between the two groups but judokas had a better fatigue resistance. This fatigue resistance can be due to the prolonged maintain of prehension in judo practices characteristics.

Our study was carried out to assess the impact of food restriction realized before a competition by French female judoka on body composition, on some factors of performance, as well as on food behavior.

2. Methods

The protocol was approved by the local ethics committee. All subjects signed a consent form that outlined the possible risks of the procedure.

2.1. Experimental protocol

In this study, the judokas were tested three times during the season: first, in January, when they were all at their normal weight (early season: ES period). The second measure took place in March (pre-competition: Pre-C period). Pre-C testing took place 24 h prior to the first competition of the season. The third measure took place 3 days after competition (post-competition: Post-C period).

Anthropometry, body composition, eating habits and sport performance measurements were assessed at each testing period.

The protocol for each period was identical.

2.2. Population

Thirteen elite female judokas of the French national training camp of Orléans (France) volunteered to participate in this study. Two groups were formed based on the subjects' claims during structured interviews: a group with weight-control practices (D group) and a group without weight-control practices (ND group). The judokas of D group applied mainly severe food restrictions to weight loss one week before each competition. D group was made up of 6 judokas (17.83 ± 1.17 years, 163.7 ± 2.8 cm, mean \pm SE) and ND group was made up of 7 judokas (17.57 ± 1.27 years, size: 159.9 ± 6.4 cm, mean \pm SE). The monthly training period was 36.5 ± 8.24 hours for the D group and 38.6 ± 11.48 hours for the ND group.

All the judoists (ND and D groups) underwent the same rigorous testing procedures.

2.3. Body weight and Body composition measurement

Body weight (BW) was measured by means of mechanical balance (Terraillon TX1500), and size by means of a height gauge. Body mass index (BMI) was calculated using the conventional formula [13]: $BMI (kg/m^2) = BW (kg)/height (m)^2$.

Body composition (i.e. fat and lean mass) was determined by skinfolds thickness measurement (triceps, calf, suprailiac, subscapular) using Harpenden caliper with the method of Durnin and Rahaman [14]. The final result was the sum of these measures. The circumference of biceps and thighs (in cm) was also determined thanks to a measure tape. All measures were realized before training session in each period.

2.4. Strength tests

The sport performance of judokas was evaluated with two strength parameters measurement (hand grip strength and power output of the legs) before training session in each period.

The hand grip strength, highlight of maintain of prehension, was measured with a dynamometer (GRIP-D T.K.K 5401) according to the manufacturer's instructions. This test consists to press the handle of the machine for a few seconds as hardly as possible. The judoka must be standing, his arm alongside the body. Four measures were realized, two with the left arm and two with the right arm, alternately. The best value was selected for analysis.

The power output of the legs, highlight of knee strength, was measured with Myotest SA [15]. This test consisted to realize a squat-jump. The judoka did a vertical jump as high as possible without countermovement lunge and knee flexed with right angle.

2.5. Food intakes

Eating habits of the judokas were studied thanks to three-days-food records during each period [16,17]. Participants were given detailed instructions on how to complete it. Diet records were checked, coded, entered and analysed using Nutrilog[®] software. The software databank is a general food directory (CIQUAL). Total energy intakes (TEI) as well as macronutrients intakes (carbohydrate, protein and fat) were determined.

2.6. Questionnaires

Three self-administered questionnaires were completed in French version: the Eating Attitude Test or EAT to detect possible eating disorders, the Questionnaire of Auto Regulation of Eating habits in Sport or QARCAS to observe the regulation of eating habits and the Questionnaire of the French Society of Sports medicine or SFMS to notice an unsuitable training. EAT questionnaire was completed once (during training period) and the two other questionnaires were completed over the three different periods.

The EAT questionnaire is composed on 26 items based on three symptoms of food disorder which it is possible to detect: diet (concern of the thinness), bulimia (bulimic behavior) and oral control (anorexia and its associated phenomena) [18]. The score was established with a Likert scale to 1 (always) to 6 (never).

The QARCAS questionnaire is composed on 16 items based on the auto regulation which represents the capacity to control its behavior or to make a success of an activity [19]. This questionnaire highlights problems of eating habits regulation. It is composed of five sub-scales corresponding to various contexts of study which influence the control of sportsmen's food attitude: food temptation, negative feelings, social interactions, compensatory strategies and the lack of anticipation of consequences on performance [20]. The score was also established with a Likert scale to 1 (always) to 6 (never).

The SFMS questionnaire is composed on 54 items which detect all the signs of overtraining as well as signs of depression, anxiety and quality of life [21]. Two responses were possible: yes or no. The score calculated is the sum of "yes".

Anonymity of questionnaires was respected.

Table 1 Physical characteristics and body composition data for D group and ND group.

		ES	PRE C	POST C
Body weight (kg)	D group	52.8 ± 3.8 ^a	50.1 ± 3.2	53.4 ± 3.7
	ND group	54.1 ± 6.1	54.0 ± 5.9	54.6 ± 5.4
BMI (kg/m ²)	D group	19.8 ± 0.8 ^a	18.7 ± 0.7 ^b	20.0 ± 0.9 ^a
	ND group	21.0 ± 1.8	21.1 ± 1.7	21.3 ± 1.6
Skin folds (cm)	D group	34.5 ± 6.5 ^a	25.8 ± 3.6 ^b	36.6 ± 6.3 ^a
	ND group	36.1 ± 8.7	36.3 ± 7.4	39.3 ± 8.2
Biceps (cm)	D group	26.2 ± 1.4	25.9 ± 1.5 ^b	26.5 ± 1.7
	ND group	27.5 ± 1.7 ^a	28.0 ± 1.4	27.8 ± 1.6
Thigh (cm)	D group	50.7 ± 1.3 ^a	49.2 ± 1.4 ^b	49.9 ± 1.6 ^b
	ND group	53.6 ± 3.7	53.3 ± 3.2	53.2 ± 3.1

D group: group with weight-control practices; ND group: group without weight-control practices; ES: Early Season; PRE C: Prior to competition; POST C: After competition.

^a difference between ES and PRE C periods or between Pre C and POST C period ($P < 0.05$).

^b difference between D group and ND group ($P < 0.05$).

2.7. Statistics

Statistica 7.1 was used for statistical analyses. A Shapiro–Wilk test was used for each variable to observe their normality. Then a Student t test or a Mann–Witney test was performed to determine the location of the differences.

Data collected were presented in mean ± SD. Significance was set as $P \leq 0.05$.

3. Results

3.1. Physical characteristics and body composition

There is no difference in body weight (BW) between the two groups whatever the measurement period (Table 1). However, for the D group, BW decreased between ES and PRE C periods.

BMI and the sum of the skin folds thickness values were lower for the D vs. the ND group in PRE C period ($P < 0.05$). Furthermore, BMI of the D group was weaker in the PRE C period than in the ES period ($P < 0.05$) and higher in the POST C period than in the PRE C period ($P < 0.05$). Besides, the sum of the skin folds thickness of the D group were lower for the PRE C period compared to the other periods and compared to the ND group for the same period ($P < 0.05$).

The measures of the circumference of biceps and thigh showed lower values of the circumference of thigh of D group for the PRE C period compared to ES period ($P < 0.05$) and also for the circumference of biceps of the ND group for the PRE C period compared to ES period ($P < 0.05$). In the PRE C period, the circumferences of biceps and thigh were lower for the D group compared to ND group ($P < 0.05$). Moreover, in POST C period, the circumference of thigh was lower for the D group compared to ND group ($P < 0.05$).

3.2. Strength tests

The hand-grip strength and the power output of the legs presented no significant inter and intra-group differences whatever the measurement period (Table 2). The hand-grip

strength values were relatively stable over the three periods for the two groups.

Concerning the power out-put of the legs, for the D group, an increasing trend was noticed over the three periods. During the ES period, the ND group value was higher than the D group value. The reverse trend was observed during the POST C period.

3.3. Food intake

Total energy intake (TEI) of the D group was lower in the PRE C period as compared to the two other periods ($P < 0.05$) (Table 3). However, there was no significant difference between the ES and POST C periods.

TEI was higher for the ND group vs. the D group in the PRE C period and lower in the POST C period ($P < 0.05$). Moreover, for the D group, TEI was lower in the PRE C period vs. the ES period ($P < 0.05$).

As regards the distribution in macronutrients, in the D group, the intake of protein, fat and carbohydrate was lower in the PRE C period compared to the ES and POST C periods ($P < 0.05$). In the ND group, fat and carbohydrate intakes were higher for the ES period vs. the PRE C period ($P < 0.05$).

If we compare the macronutrient intakes between the two groups, only the protein and fat intakes were lower for the D group vs. ND group in the PRE C period.

3.4. Questionnaires

The EAT and SFMS questionnaires did not show inter and intra-group differences (Table 4). Only the QARCAS questionnaire during the POST C period showed higher value for the D group compared to the ND group ($P < 0.05$). According to the various contexts of the eating habits, judokas of the D group had a higher score for anticipation of consequences on performance while social interactions represented the lowest score during this period. For the D group, we noticed only a decreasing trend of the score between the PRE C period and ES period and an increasing one between the POST C period and PRE C period.

Table 2 Hand grip strength (dynamometer) and power out-put of the legs (Myotest SA) data for D group and ND group.

		ES	PRE C	POST C
Dynamometer (kg)	D group	34.6 ± 3.2	34.6 ± 4.4	34.2 ± 3.5
	ND group	37.4 ± 6.2	37.7 ± 6.6	36.6 ± 7.3
Myotest (N.kg)	D group	49.8 ± 9.1	50.7 ± 8.1	53.8 ± 17.6
	ND group	52.3 ± 16.1	54.5 ± 11.2	49.2 ± 12.9

D group: group with weight-control practices; ND group: group without weight-control practices; ES: Early Season; PRE C: Prior to competition; POST C: After competition.

Table 3 Total energy intake (TEI) and macronutrients intakes data for D group and ND group.

		ES	PRE C	POST C
TEI (kcal)	D group	1498 ± 376.6 ^a	688 ± 368.1	1695 ± 428.4 ^a
	ND group	1985 ± 732.3 ^a	1285 ± 444 ^b	1233 ± 279.2 ^b
Protein (g)	D group	47.8 ± 13.06 ^a	27.8 ± 17.5	63.8 ± 12.1 ^a
	ND group	79.8 ± 31 ^b	51.5 ± 16 ^b	48.7 ± 13.8
Fat (g)	D group	57.3 ± 12.9 ^a	20.6 ± 12.8	63.6 ± 27.6 ^a
	ND group	75.8 ± 25.2 ^a	50.8 ± 21.3 ^b	40.7 ± 12
Carbohydrate (g)	D group	191.3 ± 63.4 ^a	99 ± 53.4	215.83 ± 39.8 ^a
	ND group	232.7 ± 113.2 ^a	153.5 ± 58.2	162.14 ± 48.3

D group: group with weight-control practices; ND group: group without weight-control practices; ES: Early Season; PRE C: Prior to competition; POST C: After competition.

^a difference between ES and PRE C periods or between Pre C and POST C period ($P < 0.05$)

^b difference between D group and ND group ($P < 0.05$).

Table 4 Questionnaires data for D group and ND group.

		ES	PRE C	POST C
SFMS	D group	3.8 ± 2.7	1.8 ± 2.1	2.7 ± 2.5
	ND group	2.8 ± 2.1	2.8 ± 2.6	2.1 ± 2.04
QARCAS	D group	56 ± 14.5	46.1 ± 8.7	54.1 ± 10.5
	ND group	46.4 ± 6.4	45.1 ± 8.6	42.8 ± 4.6 ^a
EAT	D group	104.5 ± 45.9	/	/
	ND group	135.2 ± 11.2	/	/

ES: Early Season; PRE C: Prior to competition; POST C: After competition; D group: group with weight-control practices; ND group: group without weight-control practices

^a significant inter-group ($P < 0.05$).

4. Discussion

Our results showed that weight-control practices reduce BMI and skin folds thickness in D group because of lower energy intake before competition. Nevertheless, these variations have shown no evidence of adverse implications on some performance parameters (hand grip strength and power output of the leg), which reflect maintain of prehension and knee strength.

For the D group, we observed a decrease in body weight (BW) and in BMI between the ES and PRE C periods. Moreover, during the PRE C period, BMI was lower for the D group as compared to the ND group. The skin folds thickness values and the circumference of biceps and thigh showed the same variations than BMI. Our results were similar to those obtained by Roemmich who studied body composition of wrestlers during a season of competition [8]. Two other

studies had already observed an increase of body weight during the post season and a decrease of the body circumference during pre season in wrestling [22,23].

Nevertheless, changes in body composition observed did not alter muscle performance. In fact, the hand grip strength and the power output of the legs were not significantly different on inter and on intra groups. Our results of strength test (Table 2) were in accordance with Prouteau's observations in a study carried out on effects of weight cycling according to gender [24]. The authors showed that the muscle performance of female judokas did not decrease contrary to male judokas. Female judokas had more body fat than male and weight loss affected lean body mass more than body fat. However, effects of energy manipulation (weight cycling) on performance are function of the severity and the chronicity of the food limitation. In the same way, it was observed that maximal strength was no

affected by a quickly weight loss in combat sports. Only chronic weight cycling had a negative impact on strength gain during a season [25].

Contrary to our results, a study carried out on eating habits of athletic women showed an increase of performance due to food restriction [26]. Indeed, food deprivation stimulates the hypothalamic-pituitary-adrenal axis permitting mobilization of the fast energy resources which are favourable to muscular endurance. The category of sport, the training and the competition levels were certainly different between Johnson's study and ours. In Franchini and al study two wrestling competing levels were compared. For a regional competition, the wrestlers who had better results lost more weight. At the opposite, for a national competition, the amount of weight loss and regain had no effect on results [25].

Practice of judo, and more particularly participation in competitions, incites some judokas to realize weight cycling [27,28]. This concept has been defined by Nitzke and corresponds to repeated episodes of weight loss and regains [29]. In fact, judokas of the D group tried to lose weight prior to a competition for fighting in the category that they judged the most favourable to achieve a competitive advantage. After the competition, the judokas recognized to regain weight quickly due to a decrease of attention in their food. This pre-competitive period is a phase of food restriction. The post-competitive weight gain demonstrates a relaxation of food constraints [30].

During the ES period, the total energy intake (TEI) was lower for the D group than the ND group but this result was not significant. However, during the PRE C period, the TEI of the D group was less than half that the one of the ND group.

TEI decreased more between the ES and the PRE C periods for the D group than for the ND group. Moreover, only for the D group, TEI increased between PRE C and POST C periods.

For this group, the weight loss observed could be due to lower energy intake during the PRE C period as compared to the ES period. These results are in agreement with those of Roemmich. They studied wrestler's energy intakes and observed that during the season of competition, these represent 50% of intakes of the early season. Elsewhere, the energy intake was similar between early season and post season [8].

As regards macronutrients (protein, fat and carbohydrate), for the ND group, it corresponded to the nutritional recommendations for sportsmen and women: 55 to 60% of carbohydrates, 20% of proteins and 20 to 25% of fat for sports with dominant force as judo [31]. It was not true for the D group with the protein and fat intakes lower than recommendations, whatever the considered period, and the carbohydrate intakes higher in PRE C period. In a study carried out at male judokas with national level, the distribution of macronutrients during precompetitive period is 50.9% of carbohydrates, 15.3% of proteins and 33% of fat [32]. Compared with macronutrients intakes in the PRE C period, the male judokas had more important fat intake and lower carbohydrate intake than our female judokas.

Arenhouts and al [33] showed that adolescent sports men and women are able to provide their energy requirement but macronutrients distribution is not adapted to their energy expenditure whatever the sex or the sport practices. In fact, adolescent sports men and women don't really

understand the carbohydrates roles, for example, and have mistaken beliefs about them [34].

The judokas of our study had not eating disorders. This was confirmed by no significant results to the EAT questionnaire (Table 4). In fact, the results obtained were lower at the threshold of indication of pathology (score of 20). This score threshold had already allowed classifying correctly 83.6% of cases of anorexia [35]. Considering the good reliability of the values of prediction obtained in another study [36], it was suggested using the EAT as instrument of screening rather than diagnosis when it is administered to a not clinical population [37].

Nevertheless, to reach the desired category, the D group judokas regulated their food intakes during the PRE C period but they are probably unable to benefit from a correct nutritional education.

The analysis of QARCAS showed for the female judokas with weight-control practices (D group) social interactions are rarely taken into account at their eating habits while the lack of anticipation of consequences on performance is a major problem. Some authors showed a link between auto regulation and physical activity in one part [38], and between auto regulation and weight loss in another part [39]. The inappropriate nutritional education of the judokas can be due to their age (approximately 17 years) and their school place (high school mainly) [40] that does not permit to have an appropriate diet, which would allow them to obtain better results in competition.

5. Conclusion and limits

In our study, we observed that food restriction practiced by elite female judokas had no effect on strength and power measured by a dynamometer and Myotest, in spite of modification of body composition and in BMI decrease. But we hypothesize that their knowledge about nutrition, and so the macronutrient distribution, are probably wrong due to their age [33,34]. Furthermore, we have to note that food restrictions highlighted real disorders of the auto regulation of eating habits.

Our study conducted on one competition, it would be interesting to realize the study during several competitions, even during a whole season, to observe a turned out effect on these factors of performance on female judokas. Furthermore, others parameters could be measured like elbow strength or ankle strength for a better performance analysis in judo.

Moreover, a sport nutritional education could probably improve sports performance and gradual weight loss would be healthier than rapid weight loss.

Ethical statement

The protocol of which was approved by the Ethics Committee of University of Paris Sud.

Authors' contribution

The study was designed by NR; data were collected by HZ, FP, NVR, NR and MG; data were analyzed by MG and KC; data

interpretation and manuscript preparation were undertaken by MG and NR. All authors approved the final version of the paper.

Disclosure of interest

The authors declare that they have no competing interest.

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