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Food and Fluid Intake in Adolescent Female Judo Athletes Before Competition

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Judo is a weight-class sport, meaning that there are weight-defined classes in competitions. Regular body weight restrictions and/or nutritional imbalances can alter growth and maturation states in adolescents. The aim of the present study was to estimate to what extent female judo athletes (age 16.1 ± 0.3 years) modified food and drink intakes 3 weeks and 1 week before competition. Our findings indicate that unbalanced dietary intakes and "weight cutting" might occur in female adolescent competitors. We conclude that dietary recommendations are compulsory in order to educate coaches and young judokas about adequate nutrition and safe weight control behaviors, as well as the dangers of rapid weight loss and dehydration during adolescence.

Introduction

Adolescence involves anatomic, physiological, and metabolic changes (21). The rapid growth and development that occurs has a profound effect on energy and nutrient requirements (23). Thus, a balanced and sufficient dietary intake is necessary during this period. Key nutrients needed by young people include protein to satisfy growth requirements and calcium to support bone accretion. It is even more important to follow nutritional recommendations for child athletes (3).

Judo is a weight-class sport, as are wrestling and boxing. At the onset of adolescence, a young athlete practicing Judo is classified in a specific weight category. During the next 1 or 2 years, many individuals' physical characteristics increase significantly (height and body weight), although many attempt to remain in the same weight class. Thus, most adolescent athletes in weight-class sports compete in a class below their natural physiological body weight.

Scientific information on judo athletes remains scarce. To our knowledge, there is no data on dietary habits and weight-loss strategies among adolescent judo athletes. From a practical point of view, judo athletes typically follow a program

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of reduced eating a few days before the weigh-in of a competition and then gain weight very rapidly afterward ("yo-yo" diet). Thus, 1 week before the official weigh-in, judo athletes restrict food and drink. In addition, sweating by performing intensive exercises in a rubber or plastic suit is frequently used to stimulate water-weight loss. Other strategies such as saunas and diuretics are frequently used in the attempt to "make weight." In extreme cases, fasting, cathartics, and/or vomiting can also be employed. This rapid weight loss ("weight cutting") induces a high physical stress level that could affect growth and maturation processes (8,13). At present it is unknown whether frequent and rapid weight-loss-and-gain cycles in young judo athletes alter protein metabolism in adolescents.

In order to shed light on these peculiar dietary habits and to determine whether nutritional intakes are indeed imbalanced, we compared two 7-day food records for female adolescent athletes from 1 week and 3 weeks before the French Judo Championship. To assess potential muscle proteolysis in this adolescent athlete group, nitrogen balance was calculated during each of these weeks from reported daily protein intake, urine nitrogen excretion, and estimated fecal and integumental nitrogen losses.

Methods

Participants

Nine healthy adolescent female judo athletes, ages 15–16 years, participated in this study. All were postpubescent. The participants were trained athletes (at least 3 years at the national level) and practiced between 10 and 15 hr per week. Regular Judo training consisted of a repetitive series of short and intense exercises involving agility and stretching. None of the participants were taking any medication or supplements during the protocol period. Two out of nine girls were amenorrheic for 1 year. The physical and physiological characteristics of the participants are included in Table 1. Body mass index (BMI) was calculated as weight/height^2 and expressed as kg/m^2. Percentage of body fat was estimated from skinfold measurements using a Harpenden skinfold caliper (19). Fat free mass was calculated

Table 1 Morphological Characteristics (Means ± *SEM*) of the Nine Female Judo Athletes 3 Weeks (W3) and 1 Week (W1) Before Competition

Week	Age (years)	Height (cm)	Weight (kg)	FFM (kg)	MM (kg)	FM (%)	BMI (kg/m^2)
W3	16.1 ± 0.3	163 ± 2	58.9± 3.6	45.0 ± 1.9	22.2 ± 1.2	23.3 ± 1.5	22.2 ± 1.2
W1	16.1 ± 0.3	163 ± 2	57.8± 3.1*	44.0 ± 1.6*	21.8 ± 1.1	23.1 ± 1.5	21.8 ± 1.0*

Note. FFM = fat free mass; MM = estimated muscle mass (21); FM = fat mass; BMI = body mass index: weight/(height^2); fat free mass is calculated from fat mass.
*$p < .05$ between the 2 weeks.

from fat mass. The girls and their parents were fully informed about this study and its design, and written consent was obtained following the guidelines of the Medical Ethics Committee of the Université Libre de Bruxelles.

Measurements

Total energy expenditure and dietary intake. Basal metabolic rate was calculated using the FAO equation (25). To assess their total energy expenditure (TEE), all participants completed a 7-day questionnaire that comprised questions about their habitual daily physical activities. The factorial method was used to estimate TEE (2).

Energy intake was recorded and assessed by a food questionnaire over 7 continuous days 3 weeks (W3) and 1 week (W1) before the competition. The means for each 7-day period were then calculated. Most foods were weighed before cooking or eating; when food portions were not weighed, models of foods were used to estimate portion sizes. Before the experimental protocol, a researcher gave detailed information and suggestions on how to fill in the food records. The female judo athletes were free to consume their regular meals. Detailed descriptions of all foods and beverages (including brand names) and their method of preparation were also recorded. The adolescents returned the completed food records to the laboratory. On arrival, a researcher queried each adolescent to verify that the dietary questionnaire had been completed adequately; anthropometric measurements were also taken at this time. Dietary intakes were analyzed by a trained nutritionist using *Prodiet* 5.1 (Proform, France), a professional software program that displays an analysis of the macro- and micronutrients of selected foods.

Nitrogen balance. We estimated nitrogen balance (NB) 3 weeks and 1 week before the competition in order to verify potential muscular protein use (through a negative nitrogen balance) because it is well known that NB can fluctuate in relation with energy-to-protein ratio changes. Nitrogen balance (24 hr) was determined from a single pooled urine sample for each adolescent during the last day of the 7-day food record. The complete urine volume (24 hr) was collected. The volume-weighted samples from each collection were combined for each participant.

Urine was collected in bottles we provided that contained 15 ml hydrochloric acid 6M to preserve urinary ammonia. In order to validate the completeness of the 24 hr urine collections, 4-aminobenzoic acid (200 mg capsule of PAB) was ingested with water by each participant in the morning after voiding. Three weeks (W3) and 1 week (W1) before the competition, urine was collected on a training day (the fourth day of the dietary assessment). Total nitrogen content of the urine was determined in duplicate using a micro-Kjeldhal technique (Büchi Nitrogen Determination System, Switzerland). Apparent nitrogen balance was estimated by subtracting urine nitrogen output from dietary nitrogen intake predicted from the diet data. For practical reasons, fecal and integumental nitrogen losses were not collected from our athletes. Generally, daily sweat and fecal losses amount to approximately 12 and 22 mg/kg of body weight, respectively, in adolescents (12). These values of estimated integumental and fecal losses were used to correct for inconsistencies in the nitrogen intake and urinary nitrogen loss data in the present investigation. The apparent nitrogen balance was established using the daily protein intake corresponding to the day of the urine collection.

Statistical Analysis

All statistical analyses were performed by the Statistica® software program for Windows®. Statistical analysis comparing the 2 weeks covered by the questionnaires was performed using the nonparametric Wilcoxon test. All data are presented as means ± standard errors of the mean (*SEM*); p values < .05 were considered statistically significant.

Results

Table 1 indicates the morphological data of the female adolescent judo athletes. As compared with classical data obtained in healthy 16-year-old girls (23), the mean weight of our participants was slightly above the range of a normal population (normal range: 163 cm, 55 kg). The mean weight loss between the 2 weeks was 1.1 kg ± 0.5 (–2% of body weight). The BMI and fat free mass were altered by the restricted diet (–2% and –2%, respectively). No significant differences were observed between W3 and W1 for fat mass (%) or estimated muscle mass.

As shown in Table 2, daily energy intake (EI), expressed as kcal (or kJ), decreased 19.7% in W1. During that week, the EI was lower than that recommended for girls of 16 years of age (2,23) and did not compensate for estimated TEE. No difference in TEE was observed between the 2 weeks studied.

The relative distribution of total carbohydrates was not different between W3 and W1, but the absolute amount of carbohydrates consumed (in g) was 24% lower in W1. Expressed in g/day, the total lipid intake and the polyunsaturated and saturated fatty acid fractions were reduced in W1. The proportion of lipid and polyunsaturated fatty acids, however, was not different between the 2 weeks. The fraction of saturated fats decreased by 7.5%, and the monounsaturated fat proportion was increased by 10.5% ($p < .05$) on W1. Even so, monounsaturated fat was still under the usual recommended allowance (2). There was no difference in the total intake of protein between the 2 weeks (± 63 g, or 1.1 $g \cdot kg^{-1} \cdot day^{-1}$) and the intake was greater than the recommended daily protein allowance (44g, or 0.8$g \cdot kg^{-1} \cdot day^{-1}$). The animal/vegetal protein ratio showed an increase of meat consumption during W1.

Daily intake of minerals, vitamins, and fiber were no different 3 weeks and 1 week before competition (Table 3). The adolescents had a lower daily intake of calcium, magnesium, iron, zinc, copper, iodine, vitamin E, and fiber as compared with the recommended values for a normal population (2,17,18,23).

Table 4 shows the water consumption and urinary excretion 3 weeks and 1 week before the French judo Championship. Water intake was reduced during W1 because of restricted drink consumption (–8.5%). Accordingly, urinary excretion was lower (–58%) during W1. Apparent nitrogen balances were not different between W3 and W1 (Table 5), which corresponded to similar protein intake for the 2 weeks.

Discussion

The objective of this study was to shed light on the dietary habits of female adolescent judo athletes 3 weeks and 1 week before the French Judo Championship and to assess unbalanced nutritional intakes and potential muscular proteolysis in

Table 2 Reported Mean Daily Energy Intake, Energy Expenditure, and Relative Nutrient Distribution (Means ± *SEM*) in Nine Female Adolescent Judo Athletes 3 Weeks (W3) and 1 Week (W1) Before Competition

Parameters	W3	W1	Difference	Normal range
Energy intake				
kcal/day	2,076 ± 206	16,66 ± 156	$p < .01$	2,000–2,500[b]
(kJ/day)	(8,679 ± 861)	(6,963 ± 651)	$p < .01$	(8,360–10,400)[b]
$kcal \cdot kg^{-1}$ day^{-1}	35.5 ± 2.6	28.8 ± 2.1	NS	
($kJ \cdot kg^{-1}$ day^{-1})	(148 ± 11)	(120 ± 89)	NS	
Basal metabolism				
kcal/day	1,436 ± 32	1,428 ± 27	$p < .05$	1,500–1,600[c]
(kJ/day)	(6,009 ± 132)	(5,975 ± 112)	NS	
Total energy expenditure[a]				
kcal/day	2,544 ± 52	2,607 ± 134	NS	
(kJ/day)	(10,633 ± 246)	(10,897 ± 187)	NS	
$kcal \cdot kg^{-1}$ day^{-1}	43.2 ± 2.1	45.1 ± 2.0	$p < .05$	
($kJ \cdot kg^{-1}$ $day^{-1)}$	(180 ± 10)	(188 ± 19)	$p < .05$	
Proteins (%)	12.3 ± 0.5	15.2 ± 0.9	$p < .05$	15%[d]
g/day	65.6 ± 8.2	61.7 ± 4.5	NS	
$g \cdot kg^{1} \cdot day^{1}$	1.12 ± 0.12	1.07 ± 0.1	NS	0.8–1.0[d, b]
animal/vegetal (g)	1.61 ± 0.18	2.75 ± 0.26	$p < .01$	> 1[d]
Lipids (%)	34.9 ± 2.1	35.3 ± 2.5	NS	30%[d]
g/day	81.8 ± 10.9	66.7 ± 8.9	$p < .01$	
Fatty acids (%)				
saturated	45.2 ± 1.1	41.9 ± 1.8	$p < .05$	25%[d]
monounsaturated	39.4 ± 1.1	43.5 ± 1.7	$p < .05$	60%[d]
polyunsaturated	15.0 ± 0.6	14.3 ± 0.8	NS	15%[d]
Cholesterol	305 ± 51	225 ± 38	$p < .01$	
Carbohydrates (%)	52.8 ± 2.4	49.4 ± 2.3	NS	55%[d]
g/day	259.5 ± 22.5	197.2 ± 19.6	$p < .01$	
Simple sugars (% of EI)	26.9 ± 2.1	26.1 ± 1.9	NS	10%[d]

Note. FA = fatty acids; EI = energy intake.
[a]Daily energy means from a 7-day survey (8); [b]source: Recommended Dietary Allowances in Normal Children 16 to 19 years old (2);[c]source: Basal Metabolism for Normal Girls 16 Years old (7); [d]source: Normal Distribution of Nutrients (8).
*$p < .05$ (significant differences between the 2 weeks); **$p < .01$ (significant differences between the 2 weeks); NS: no significant differences between the 2 weeks.

Table 3 Daily Dietary Intake of Minerals, Fiber, and Vitamins 3 Weeks (W3) and 1 Week (W1) Before Competition for Nine Female Judo Athletes (Means ± *SEM*)

Parameters	W3	W1	Normal range[a]
Calcium (mg)	966 ± 94	860 ± 66	1,200
Phosphorus (mg)	1,138 ± 11	1,046 ± 63	800
Magnesium (mg)	**261 ± 27**	**227 ± 19**	**370**
Iron (mg)	10.3 ± 1.1	10.41 ± 1.4	16
Zinc (μg)	**5.9 ± 0.7**	**6.5 ± 0.9**	**10**
Copper (mg)	1.19 ± 0.10	1.01 ± 0.08	1.5
Iodine (μg)	**63.5 ± 1112**	**100.9 ± 9.7**	**120**
Thiamin (mg)	1.09 ± 0.09	1.19 ± 0.15	1.1
Riboflavin (mg)	1.76 ± 0.20	1.75 ± 0.20	1.5
Vitamin B6 (mg)	1.44 ± 0.15	1.74 ± 0.21	1.5
Vitamin B12 (μg)	4.37 ± 0.64	4.42 ± 0.52	2.0
Folate (μg)	244 ± 30	270 ± 32	200
Vitamin B5 (mg)	4.2 ± 0.4	4.0 ± 0.3	4.5
Niacin (mgEN)	11.35 ± 1.27	14.34 ± 2.11	11
Vitamin A (μgER)	676 ± 122	633 ± 33	600
Vitamin D (μg)	10.23 ± 1.22	10.11 ± 1.07	5
Vitamin C (mg)	99.1 ± 18.4	127.6 ± 19.2	110
Vitamin E (mg)	6.59 ± 0.86	6.43 ± 0.75	12
Total fiber (g)	14.15 ± 1.40	12.51 ± 0.95	25-35

Note. Values in bold are below the normal range; no differences appeared between the 2 weeks.
[a]Source: Recommended Dietary Intakes in normal girls of 15–16 years old (2,10,11,20).

Table 4 Daily Water Consumption and Urinary Excretion 3 Weeks (W3) And 1 Week (W1) Before Competition for Nine Female Judo Athletes (Means ± *SEM*)

Parameters	W3	W1	*p*
Water consumption (L)	4.22 ± 0.41	3.87 ± 0.18	< .01
from drinks	1.90 ± 0.14	1.55 ± 0.13	< .05
from food	2.32 ± 0.09	2.36 ± 0.12	NS
Urinary excretion (ml)	1,705 ± 358	709 ± 89	NS

Table 5 Protein Intake, Nitrogen Excretion, and Nitrogen Balance 3 Weeks (W3) And 1 Week (W1) Before Competition for Nine Female Judo Athletes (Means ± *SEM*)

Parameters	W3	W1	*p*
Total protein intake[a]			
g/day[b]	65.8 ± 11.2	62.4 ± 4.6	NS
(g/kg·bodyweight/day)	1.12 ± 0.18	1.10 ± 0.10	NS
N (g/day)	10.53 ± 1.79	9.98 ± 0.73	NS
Total N excretion*			
g/day	9.68 ± 1.16	10.89 ± 0.83	NS
Apparent N balance			
g/day	0.85 ± 0.43	–0.92 ± 0.64	NS
(g/kg bodyweight/day)	0.02 ± 0.02	–0.02 ± 0.01	NS

Note. N = nitrogen.
[a]Calculated from Prodiet 5.1 (software; Nutriform, France); [b]the normal range in girls of 15–16 years old is 44 g (2).
*Protein is assumed to be 16% N.

this population. In order to qualify for their weight class, the athletes had to rely on restricted food and fluid intakes the week before the weigh-in of the competition. Our study showed that lean body mass and fat mass were not significantly altered by weight cutting. Apparently, the observed weight loss was predominantly linked to an acute dehydration process.

Judo is a dynamic sport that requires complex skills and tactical excellence for performance. It is characterized by repeated short-duration high-intensity intermittent efforts that last approximately 8 min per competition (22). Thus, judo requires a high degree of aerobic and anaerobic conditioning (24). The estimated TEE in female adolescent judo athletes was similar 3 weeks and 1 week before the competition. When expressed as $kcal \cdot kg^{-1} \cdot day^{1}$, however, the TEE was greater in W1. The dietary intake was assessed by a 7-day food-record questionnaire together with interviews. The intake information for the questionnaire was obtained by weighing most food portions. During the week before the competition, 8 of 9 participants had to lose weight (a mean loss of about 2.3 kg) in order to qualify for their weight class. Thus, the restricted food intake in W1 was clearly a decision made deliberately by the athletes.

The nutritional intakes indicated unbalanced carbohydrate and lipid proportions in W3 and W1. The protein intake (% of EI) was slightly insufficient in W3 (about 12%) but well adapted in W1 (15%). The recommended distribution of macronutrients in adolescent athletes represents 55– 60% of the total energy for carbohydrates, 25–30% for lipids, and 15% for proteins (20). The relative percentage of carbohydrates in W3 (53%) seemed to be sufficient to maximize glycogen storage (9). In W1, however, both the percentage and the total amount of carbohydrate were reduced (–6.5%), and they were lower than the recommended allowances (2). Furthermore, as previously reported in adolescent athletes (7), simple sugar intake was much higher in our adolescent girls (26% instead of the recommended 10%), whereas carbohydrates with a low glycemic index (complex carbohydrates) were in deficit. Thus, the restricted diet in W1 might induce a significant decrease in muscle and liver glycogen content just before the competition. The mean daily fiber intake was not different between the time periods and reached 12.5–14 g/day, which is lower than the recommended allowances.

The fat proportion ingestion was not different between W3 and W1 (35% of the total EI). The total amount of lipids (g), however, decreased (–18.5%) in W1. Despite a more predominant use of fat during exercise in children (6), there is no data suggesting that children need greater lipid intakes than do adults. Therefore, lipids are probably overconsumed as compared with complex carbohydrates in both W3 and W1. Incidentally, the relative proportion of mono-, polyunsaturated, and saturated fatty acids was better adapted in W1.

The proportion of protein ingested was higher in W1 than W3 (15% of EI in W1 compared with 12% in W3). When expressed in g/day, however, the total amount of protein ingested was similar in W3 and W1. The proportion of animal protein to vegetal protein ingested increased 71% from W3 to W1, indicating a significant increase in animal protein consumption. Protein during both weeks was 25% greater than the recommended allowance ($1.1\ g \cdot kg^{-1} \cdot day^{-1}$ vs. $0.8\ g \cdot kg^{-1} \cdot day^{-1}$; 2,22). As a consequence, the apparent nitrogen balance was positive during the 2 weeks studied and probably indicated no muscular protein use before the competition (0.85 ± 0.43 and $–0.92 \pm 0.64$ in W3 and W1, respectively). This result suggests that the amount of protein ingested would prevent proteolysis before the competition. This might explain the stability in estimated muscle mass even with the restricted W1 diets of our adolescent female judo athletes.

In physically active children, the daily food ration must provide vitamin B6, vitamin D, iron, calcium, phosphorus, and magnesium in order to promote growth and sustain a high level of physical activity (4,5). In our study, there were no significant differences between W3 and W1 in mineral, vitamin, and fiber intakes. Calcium, magnesium, iron, zinc, copper, iodine, and vitamin E intakes, however, were under the recommended allowances for female adolescents of 15–16 years of age (2,16,17,18). Thus, even in a standard training week without weight cutting (W3), some deficiencies appeared in our adolescents' diets that might be prejudicial for their development, maturation, and performance.

The expected benefit of diet restriction in judo athletes appears to be a rapid weight loss that allows the athletes to qualify to fight in a specific category. Consequently, not only are food intake restrictions imposed on the participants, but fluids are restricted as well. Moreover, during the week just before the competition, 8 out of 9 judo athletes in our study used plastic underwear under their judo suit to stimulate water loss. Saunas, cathartics, and vomiting, however, were not used. The mean weight loss in our study was 1.09 ± 0.50 kg. The percentage of fat mass did not change between W3 and W1, but the fat free mass was reduced by 2.2%. An unaltered skeletal muscle mass in W1, which was shown by the nitrogen balance results and the estimation of total skeletal muscle mass (15), provided evidence that the weight loss was related to acute dehydration in these adolescent female judo athletes. In our study the total amount of urinary excretion was significantly reduced in W1 as compared with W3 (down 58%). Lower urine volume excretion and greater sweat production because of the plastic suits worn during physical training were indications of dehydration. The technique of fluid deprivation and sweating are well known by athletes competing in a weight-class sport (13).

Our judo athletes practiced these weight-loss strategies in order to remain in their weight category, hoping for better success. Ironically, weight cutting might impair performance and endanger the judoka's health. In our study, weight loss could probably be attributed to reduction in body water and glycogen storage. Food and drink restrictions induce a combined negative effect on physical and psychological capacities. Judo athletes attempt to replenish body fluids, electrolytes, and glycogen in the brief period (1–3 hr) between the weigh-in and the competition. Reestablishing fluid homeostasis and replenishing muscle glycogen, however, might take 24–48 hr (23) or even longer (11,14). Thus, cutting weight appears to adversely affect the judoka's energy reserves and fluid and electrolytes balances and could alter performance.

The effects of rapid weight loss and dehydration on physiological performance are well documented (1). This practice could cause several things: a reduction in muscle strength and anaerobic power capacity; increased resting and submaximal heart rate; decreased cardiac stroke volume resulting in decreased ability to sustain work at a constant rate; lower oxygen consumption; impaired thermoregulatory processes; lower plasma and blood volume; depletion of muscle and possibly liver glycogen; difficulty of glucose homeostasis; altered hormonal status; reduced immune function; and so forth. (1). For all of these reasons, it seems important to educate coaches and judo athletes in sound nutrition and weight control practices and to curtail weight cutting in order to avoid adverse effects in young participants' growth and maturation. Scientists, physicians, dieticians, coaches, athletic administrators, trainers, and other health professionals should work together to change the attitudes that support practices harmful to the athletes.

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