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Original Article

Changes in Physical Characteristics, Hematological Parameters and Nutrients and Food Intake during Weight Reduction in Judoists

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Abstract

We studied changes in physical characteristics: body composition; muscle and physical strength; hematological parameters; and nutrients and food intake in 22 male college judoists who were losing weight purposefully. Nutritional parameters in blood, such as triglycerides, decreased immediately before matches and rebounded after matches. Free fatty acid increased before matches and returned to previous levels 10 days after matches. IgM and complements decreased before matches and did not return to previous levels even 10 days after matches. These changes were noted in the marked weight reduction group (weight lost / body weight before weight reduction, weight reduction rate≧6%). In contrast, creatine kinase increased before matches in the slight and moderate weight reduction groups (weight reduction rate< 3% , 3≦and< 6%, respectively). The marked weight reduction group showed no changes in creatine kinase, however, indicating inadequate exercise due to excessive weight reduction. Muscle strength (grip) and nutrients and food intake decreased significantly before matches. These changes were noted in the marked weight reduction group. These findings suggested that a weight reduction rate of 6% or more adversely affected the performance and health of the judoist.

Key words: judoist, weight reduction, hematological parameter,nutrients and food intake, physical characteristic

Introduction

Judo did not have weight classification until 1961, when judo became an official Olympic event. Nowadays a weight classification of seven classes is in use. Judoists should, in theory, select the weight class most appropriate to their physique. Many often select a lower weight class, however, to gain an advantage over other judoists in the class.

Optimally, the judoist should be able to lose the necessary amount of weight without reducing performance. Weight loss, including water restriction, reportedly decreases basal metabolism which affects anaerobic power and aerobic power associated with sports performance[1-8]. A lack of proper knowledge on how to lose weight harmlessly may often decrease an athlete's performance.

While most previous physiological studies on weight reduction have used wrestlers[1-6] and boxers[7,8] as subjects, we conducted a dietary survey and measurement of body composition, muscle and physical strength, and hematological parameters during purposeful weight loss in male college judoists and its influence on performance and health.

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Subjects and Methods

Subjects

Subjects were 22 male judoists (mean age: 20.1 years) who belonged to the Nippon Sport Science University Judo Club. They competed in the National Judo Championship Tournament by Weight Class of Japanese Colleges of Physical Education held February 25, 1995. Five students were in the ≦60

Table 1 Degree of weight reduction in subjects.

Subject number	Age	Height (cm)	Body weight (kg)[a]	Weight class (kg)	Body weight 4 days before(kg)[b]	Degree of weight reduction
1	21	167.3	65.0	60 or below	61.1	marked[c]
2	21	169.9	65.0	60 or below	61.1	marked
3	19	162.6	68.5	60 or below	65.8	moderate[d]
4	20	158.7	64.4	60 or below	62.2	moderate
5	18	165.4	63.0	60 or below	61.6	slight[e]
6	21	170.7	72.0	65 or below	67.7	marked
7	21	169.4	69.0	65 or below	66.5	moderate
8	20	167.4	70.9	65 or below	66.6	marked
9	20	169.3	77.0	71 or below	72.4	marked
10	21	167.6	72.8	71 or below	71.3	slight
11	21	170.2	73.0	71 or below	71.6	slight
12	20	174.5	82.3	78 or below	79.1	moderate
13	21	182.8	85.0	78 or below	79.9	marked
14	19	173.2	83.1	78 or below	81.5	slight
15	20	169.6	83.3	78 or below	80.7	moderate
16	20	182.5	90.7	86 or below	87.3	moderate
17	19	182.4	85.4	86 or below	83.7	slight
18	20	177.4	88.4	86 or below	87.5	slight
19	21	177.5	93.1	86 or below	91.5	slight
20	21	174.4	95.5	95 or below	92.6	moderate
21	19	178.5	96.8	95 or below	94.9	slight
22	20	184.5	100.4	95 or below	96.7	moderate

[a] body weight before weight reduction [b] body weight 4 days before matches [c] marked weight reduction [d] moderate weight reduction
[e] slight weight reduction

kg class, 3 in the ≦65 kg class, 3 in the ≦71 kg class, 4 in the ≦78 kg class, 4 in the ≦86 kg class, and 3 in the ≦95 kg class. The mean weight reduction goal for all subjects was 4.3 kg (Table 1).

Methods

Hematological parameters, body composition, and muscle and physical strength were measured 4 times: 50 days before matches (before weight reduction), 20 days before (weight loss was initiated by changes in training and diet), 4 days before (immediately before matches), and 10 days after matches. A dietary survey was conducted daily from 7 weeks before matches to one week after.

1) Hematological parameters

Blood samples were collected before meals in the early morning to gauge the following 12 parameters: hemoglobin concentration (Hb), leukocyte count (WBC) and hematocrit (Ht) in whole blood (Coulter MD II, Coulter Co. Ltd., Tokyo); total protein (TP, Biuret method), creatine kinase (CK, Ultraviolet method), total cholesterol (T-Cho, CHOD-PAP method), triglyceride (TG, GK-GPOD-POD method), free fatty acid (FFA, ACS-ACO method), immunoglobulin G (IgG, nepherometry method), immunoglobulin M (IgM, nepherometry method), C3 complement (C3, nepherometry method) and C4 complement (C4, nepherometry method) in serum.

2) Body composition

To measure body composition, body density was determined by weighing in water[9]. Body density was calculated using the following equation:

body density = BWA/[(BWA - BWW)/water density-residual air volume-100 mL]

BWA: body weight in air, BWW: body weight in water.

Residual air volume was calculated by rebreathing method with pure oxygen using nitrogen concentration as a reference[10]. The percentage of body fat (%fat) was calculated from body density by the formula of Brozek et al.[11], and body weight was multiplied by %fat to obtain body fat mass. The lean body mass (LBM) was then obtained by subtracting body fat mass from body weight.

3) Muscle and physical strength

The following judo-associated parameters were measured: grip (right), dorsal muscle strength, elbow flexor strength (right) and vertical jump. To evaluate anaerobic work capacity, maximum anaerobic power (high power) and mean power for 40 seconds (middle power) were measured by pedaling at full speed using a bicycle ergometer (Power Max V, Combi Co., Ltd., Tokyo). High power was measured using the built-in maximum anaerobic power test program of the Power Max V. In this program, the initial load is fixed based on the subject's body weight and three 10-second periods of pedaling are performed at 120-second intervals. Loads for the second and third pedaling trials were increased based on rotation rates for the first and second pedaling trials, and the maximum anaerobic work capacity was determined from 10-second full-speed pedaling 3 times using 3 different loads[12]. Middle power was measured from full-speed pedaling for 40 seconds using a load equal to 7.5% of the subject's body weight. The rotation rate was recorded at 5-second intervals, and mean power for 40 seconds was calculated as middle power[13].

4) Nutrients and food intake

Meals and their weights were recorded daily in a dietary survey table by each subject, and food intake weight per day calculated. The intake of nutrient per food weight was calculated and added to obtain the nutrient intake per day. The fourth revision of the food composition table[14] was used for calculating energy and nutrients (carbohydrates, fat, and protein).

Table 2 Changes in body composition according to weight reduction percentage.

Measurement item	50 days before matches	20 days before matches	4 days before matches	10 days after matches
marked weight reduction group(≧6%),n=6				
Body weight(kg)	72.5±7.0	71.1±6.7	68.2±6.6*	71.3±7.0
% fat(%)	11.3±3.3	10.8±3.7	9.0±3.8*	8.7±3.4
Body fat(kg)	8.3±2.9	7.8±3.2	6.3±2.9*	6.3±3.2
LBM(kg)	64.1±5.2	63.2±4.7	61.9±5.2*	64.9±5.1
moderate weight reduction group(3≦and＜6%),n=8				
Body weight(kg)	81.8±12.5	81.4±12.1	78.9±12.2*	80.8±11.6
% fat(%)	13.2±4.1	12.9±5.2	11.5±4.1*	12.3±3.3
Body fat(kg)	11.2±4.7	10.9±5.6	9.4±4.4*	10.2±3.8
LBM(kg)	70.5±8.0	70.4±8.4	69.4±8.7	70.5±8.7
slight weight reduction group(＜3%),n=8				
Body weight(kg)	82.0±10.7	81.6±10.3	80.5±10.8	81.1±10.1
% fat(%)	11.0±5.0	10.8±3.9	10.4±4.2	11.4±6.0
Body fat(kg)	9.5±5.3	9.1±4.3	8.8±4.5	9.5±5.4
LBM(kg)	72.4±6.4	72.4±6.9	71.6±7.2	71.5±7.8
Total,n=22				
Body weight(kg)	79.3±11.4	78.7±11.2	76.5±11.6*	78.3±10.9
% fat(%)	11.9±4.4	11.6±4.5	10.4±4.2*	11.0±4.7
Body fat(kg)	9.8±4.7	9.4±4.7	8.3±4.3*	8.9±4.6
LBM(kg)	69.4±7.8	69.2±7.9	68.1±8.3*	69.4±8.0

%fat: percentage of bodty fat, LBM: lean body mass.
Values are means±S.D.
Significant differences from 50-days-before values(*p<0.05)

Table 3 Changes in physical performance according to weight reduction percentage

Measurement item	50 days before matches	20 days before matches	4 days before matches	10 days after matches
marked weight reduction group(≧6%),n=6				
Grip,right(kg)	44.8±11.0	46.8±8.1	38.3±6.9*	41.3±11.8
DMS(kg)	163.5±23.4	153.2±30.0	165.8±20.7	161.8±23.5
EFS,right(kg)	23.7±2.9	24.3±2.5	25.2±2.9	23.8±2.4
Vertical jump(cm)	56.8±5.6	55.8±5.6	51.3±5.7	53.7±4.5
MAP(w)	863±88	910±143	839±129	828±57
Middle power(W)	592±66	570±48	578±59	571±65
moderate weight reduction group(3≦and＜6%),n=8				
Grip,right(kg)	46.2±10.0	45.1±7.8	40.6±6.9	39.9±10.4
DMS(kg)	171.6±20.2	160.4±13.9	167.5±23.4	168.1±22.8
EFS,right(kg)	23.1±5.2	24.9±7.6	24.5±6.9	26.1±5.6
Vertical jump(cm)	56.9±6.0	57.6±7.7	56.8±4.1	56.6±5.2
MAP(w)	894±106	926±80	938±117	960±27
Middle power(W)	645±83	625±70	619±61	625±87
slight weight reduction group(＜3%),n=8				
Grip,right(kg)	50.1±7.0	52.8±5.7	47.7±3.8	44.2±3.7
DMS(kg)	167.6±13.5	160.6±15.0	159.7±15.6	165.6±7.7
EFS,right(kg)	27.6±3.2	31.0±5.2	30.0±3.1	29.9±3.1
Vertical jump(cm)	59.3±5.75	58.9±4.9	58.0±5.7	56.3±4.8
MAP(w)	918±120	959±100	978±127	967±22
Middle power(W)	650±69	606±48	628±59	631±82
Total,n=22				
Grip,right(kg)	47.1±9.7	48.2±8.0	42.3±7.2*	41.7±9.4*
DMS(kg)	168.0±19.6	158.4±20.4	164.4±20.6	164.9±19.0
EFS,right(kg)	24.8±4.5	26.8±6.5	26.5±5.5	26.7±4.7
Vertical jump(cm)	57.7±5.9	57.5±6.4	55.6±5.8	55.7±5.0
MAP(w)	893±108	932±110	923±136	925±126
Middle power(W)	631±78	603±61	610±63	612±84

DMS: Dorsal muscle strength, EFS: Elbow flexor strength,
MAP: Maximal anaerobic power
Values are means±S.D.
Significant differences from 50-days-before values(*p<0.05)

5) Statistical analysis

Results were expressed as mean ± standard deviation. Differences in means were analyzed by the one-way analysis of variance. P values of less than 0.05 were considered significant.

Results

Body weight and body composition (Table 2)

The mean body weight of the 22 subjects decreased by 0.6 kg 20 days before matches and by 2.8 kg 4 days before, compared to 50 days before matches. Body fat weight decreased by 0.4 kg 20 days and 1.5 kg 4 days before matches, compared to 50 days before. In order to analyze results in this study according to the degree of weight reduction, all subjects were divided into three groups by weight reduction rate by percentile: one is a marked weight reduction group (weight reduction rate, WRR≧6%, 6 subjects), one is a moderate weight reduction group (WRR 3≦ and＜6%, 8 subjects), and one is a slight weight reduction group (WRR＜3%, 8 subjects).

Muscle and physical strength (Table 3)

The mean right-side grip decreased significantly 4 days before and 10 days after matches (both $p<0.05$). No significant changes were observed in other parameters.

Hematological parameters (Table 4)

Mean Hb value increased significantly 4 days before matches ($p<0.05$) while Ht did not change significantly during weight reduction. WBC decreased slightly 4 days before matches, but was not significant. CK, a muscle release enzyme, increased significantly 4 days before matches ($p<0.05$). Among fat-associated parameters, TG and T-Cho decreased significantly 4 days before matches ($p<0.05$) and only TG rebounded after matches. Mean FFA increased significantly 4 days before matches ($p<0.01$) and returned to mean previous level 10 days after. Among immunity-associated parameters, IgM and complements (C3, C4) decreased significantly 4 days before matches ($p<0.05$) and did not return to previous levels even after 10 days.

In the marked weight reduction group, the above trends dominated, whereas the slight weight reduction group showed similar patterns of change but at lower rates. The moderate weight reduction group showed values between the slight and marked weight reduction groups. CK increased before matches in the slight and moderate weight reduction groups but showed no significant change in the marked weight reduction group.

Nutrients and food intake (Table 5)

The mean energy intake was 2024 kcal 7 weeks before and 2101 kcal 3 weeks before matches, however, it decreased to 1825 kcal 2 weeks before and 1355 kcal one week before matches which was statistically significant ($p<0.01$) when compared to the value seven weeks before matches. It increased again to 2109 kcal one week after. Patterns of change in carbohydrates, fat, and protein

were similar to those in energy. The carbohydrates/energy ratio increased slightly while fat and protein/energy ratios decreased slightly before matches, although not significantly. Rice and meat intake were decreased markedly one week before matches ($p<0.01$). This trend was noted in the marked weight reduction group.

Results in the competition

The results of all subjects in this judo competition were shown in Table 6. In the moderate and slight weight reduction groups, two subjects respectively got championship. However, in the marked weight reduction group, all 6 subjects could not reach the final match.

Discussion

Body weight and body composition

Mean body weight decreased by 2.8 kg 4 days before matches, compared to 50 days before. However, the mean weight reduction goal for all subjects was 4.3 kg. Therefore, it was necessary to lose 1.5 kg more within the remaining 4 days. Mean LBM decreased by 1.3 kg 4 days before matches, compared to 50 days before. Thus, the weight loss 4 days before matches consisted of a 53.6% decrease in fat and a 46.4% decrease in LBM. The percentage by which LBM was reduced for total weight reduction in the marked weight reduction group (53.3±7.6%) was significantly higher than that in the slight and moderate weight reduction groups (44.2±7.0%)($p<0.01$).

Hematological parameters

Four major changes were observed in hematological parameters.

Firstly, there was a decrease in serum lipids as a nutritional parameter and its associated parameters (T-Cho and TG) before matches. T-Cho, which decreases in the presence of inadequate nutrients supply, decreased significantly, suggesting a marked decrease in nutrients as a result of the restricted diet for the purpose of severe weight reduction.

Secondly, there was a decrease in immune-associated parameters (IgM, C3, and C4) before matches.

These decreases were not reported in previous studies, and indicate decreased immunocom-petence, which is disadvantageous to health management before matches. The causes of the decreases of IgM and complements are unknown, but their production may have been affected by malnutrition which causes decreased protein content in the body. Unfortunately, such decreased levels persisted even up to 10 days after matches.

Thirdly, there was an increase in muscle release enzymes (CK) before matches. Another important finding was the marked difference in CK behavior related to the degree of weight loss. In the slight and moderate weight reduction groups, CK increased before matches, but in the marked weight reduction group, it showed only negligible changes throughout the study. CK behavior after exercise is known to be related to the exercise load and the body's muscle reserves[15,16]. We observed no increase in CK in the marked weight reduction group. This may be associated with decreased exercise in this group. Under such circumstances, the absence of increase in CK suggests a decrease in the absolute exercise load. These subjects may not have practiced adequately for matches due to excessive weight loss, making this state dis-

Table 4 Changes in hematological parameters according to weight reduction percentage.

Measurement item	50 days before matches	20 days before matches	4 days before matches	10 days after matches
marked weight reduction group(≧6%),n=6				
Hb(g/dL)	17.1±1.1	16.1±1.9	17.4±1.2	16.0±0.9
Ht(%)	48.7±0.5	46.3±2.4	44.1±2.4	44.7±2.8
WBC(/mm³)	6983±843	8133±2069	6183±1150	8650±1759
TP(g/dL)	7.7±0.2	7.8±0.4	7.5±0.4	7.1±0.4
T-Cho(mg/dL)	180.3±18.3	162.0±19.5	166.7±14.7*	162.2±17.8*
TG(mg/dL)	106.8±34.8	136.0±85.7	80.2±15.7*	216.2±151.2*
FFA(mEq)	395.8±93.8	720.8±288.7**	810.5±733.2**	493.5±219.3
CK(U/L)	185.0±70.7	265.3±79.2	261.2±124.7	266.5±122.8
IgG(mg/dL)	1352±132	1348±83	1283±152	1248±142
IgM(mg/dL)	103.0±15.1	108.7±21.5	89.0±37.0*	96.8±18.7
C3 (mg/dL)	109.5±16.5	98.8±15.3	92.3±9.7*	96.3±16.6
C4 (mg/dL)	29.5±4.5	26.7±5.7	24.3±5.0*	25.8±5.0
moderate weight reduction group(3≦and<6%),n=8				
Hb(g/dL)	16.0±1.3	15.9±0.9	17.7±1.7	16.8±1.4
Ht(%)	46.6±2.9	47.9±2.1	43.7±5.3	44.1±2.7
WBC(/mm³)	6863±1006	8638±2017	6800±1094	7738±2418
TP(g/dL)	7.4±0.3	7.5±0.3	7.4±0.5	7.3±0.6
T-Cho(mg/dL)	178.0±23.2	175.8±28.9	165.5±20.0	176.1±30.0
TG(mg/dL)	98.4±30.4	140.0±109.0	75.0±21.5*	168.5±98.8
FFA(mEq)	261.8±91.9	428.8±130.8*	701.5±186.6**	259.1±100.6
CK(U/L)	524.1±975.9	374.9±124.5	467.8±153.3	264.0±193.9
IgG(mg/dL)	1228±188	1219±182	1274±226	1156±195
IgM(mg/dL)	127.1±42.1	137.6±41.7	123.1±32.7	131.6±34.2
C3 (mg/dL)	109.6±11.7	106.6±11.6	95.4±12.9	98.6±12.0
C4 (mg/dL)	30.8±5.2	30.1±5.5	25.0±5.1*	28.4±5.4
slight weight reduction group(<3%),n=8				
Hb(g/dL)	17.0±1.1	15.5±0.5	18.1±1.1	16.7±1.1
Ht(%)	48.9±1.4	46.8±2.2	46.6±4.7	43.5±2.7
WBC(/mm³)	8950±1059	5950±1057	6313±1261	9250±2128
TP(g/dL)	7.5±0.3	7.6±0.2	7.7±0.6	7.2±0.3
T-Cho(mg/dL)	178.0±17.4	165.4±14.1	156.4±23.7	153.0±23.3
TG(mg/dL)	131.6±50.8	137.4±53.3	106.3±47.2	150.9±86.2
FFA(mEq)	315.0±114.5	445.5±195.2	699.8±392.7	279.4±164.4
CK(U/L)	197.5±97.4	481.8±317.8**	437.3±220.1**	474.4±336.2**
IgG(mg/dL)	1243±155	1270±142	1262±162	1234±151
IgM(mg/dL)	129.4±24.4	129.4±23.6	113.1±22.0	118.6±26.4
C3 (mg/dL)	112.0±18.8	102.5±9.2	95.1±12.3	105.9±24.0
C4 (mg/dL)	26.0± 8.1	24.6±3.6	24.5±7.6	26.5±8.4
Total,n=22				
Hb(g/dL)	16.6±1.3	15.8±1.2	17.6±1.4*	16.6±1.2
Ht(%)	48.0±2.2	47.0±2.3	45.3±3.1	44.0±2.8
WBC(/mm³)	7655±1390	7523±2123	6414±1182	8536±2244
TP(g/dL)	7.5±0.3	7.6±0.3	7.5±0.5	7.2±0.5
T-Cho(mg/dL)	178.6±19.9	168.2±22.7	162.5±20.4*	163.9±20.9
TG(mg/dL)	112.8±42.6	138.0±85.8	87.8±35.3*	175.1±140.0
FFA(mEq)	318±114	515±243*	731±467**	330±192
CK(U/L)	313±614	384±227	400±194*	341±263
IgG(mg/dL)	1267±170	1273±154	1272±186	1209±171
IgM(mg/dL)	121.4±32.4	126.7±33.1	110.2±33.5*	117.4±31.1
C3 (mg/dL)	110.5±16.0	103.0±12.4	94.5±12.0*	100.6±18.8
C4 (mg/dL)	28.7±6.6	27.2±5.5	24.6±6.1*	26.0±5.9

Values are means±S.D.
Significant differences from 50-days-before values(*$p<0.05$, **$p<0.01$)

Table 5 Changes in intake of nutrients and food groups according to weight reduction percentage

Nutrients & food group	7 weeks before matches	4 weeks before matches	3 weeks before matches	2 weeks before matches	1 week before matches	1 week after matches
marked weight reduction group(≧6%),n=6						
Total energy and nutrients						
Energy(kcal)	1939±367	2418±482	2052±551	1796±302	1037±291**	2509±776
Protein(g)	67±13	74±14	61±14	60±10	32±11**	60±11
Fat(g)	56±20	70±21	63±20	56±21	28±14**	53±18
Carbohydrate(g)	284±68	365±103	305±90	256±39	165±37*	442±154
ESC(%)	57.8±7.7	60.3±7.9	58.5±5.1	58.5±6.5	67.3±10.1	66.5±5.2
Food groups						
Rice(g)	476±83	509±97	419±123	361±87	163±120**	425±149
Meats(g)	83±48	99±48	82±47	76±53	33±34**	102±55
Drinks(g)	233±155	233±147	287±204	236±193	416±165*	408±256
moderate weight reduction group(3≦and<6%),n=8						
Total energy and nutrients						
Energy(kcal)	2237±812	2622±684	2660±381	2276±522	1568±438*	2651±454
Protein(g)	76±29	76±17	81±14	68±18	43±15*	89±17
Fat(g)	70±38	67±25	68±13	60±19	46±18*	78±21
Carbohydrate(g)	310±122	419±140	422±72	360±87	243±63	384±66
ESC(%)	54.7±13.3	63.5±8.4	63.1±5.0	64.7±7.6	62.5±7.81	58.3±5.3
Food groups						
Rice(g)	591±324	580±121	613±136	454±165	270±128**	721±149
Meats(g)	180±118	120±63	98±49	83±48	44±27**	141±40
Drinks(g)	284±211	566±306	625±350	508±231	509±217*	113±127
slight weight reduction group(<3%),n=8						
Total energy and nutrients						
Energy(kcal)	2335±651	2258±466	2197±408	1945±422	1764±358*	2088±344
Protein(g)	69±17	70±13	74±15	60±14	55±11	72±12
Fat(g)	70±27	59±18	72±23	59±19	52±17	50±13
Carbohydrate(g)	350±100	352±84	305±58	287±60	261±47	327±55
ESC(%)	59.9±7.1	61.5±6.5	55.9±6.9	60.5±6.3	63.0±6.0	63.0±3.6
Food groups						
Rice(g)	532±136	519±108	524±119	482±119	344±119*	584±67
Meats(g)	111±82	98±45	129±64	80±50	76±47	74±59
Drinks(g)	437±256	405±189	330±262	381±192	231±169	295±181
Total,n=22						
Total energy and nutrients						
Energy(kcal)	2024±632	2222±753	2101±622	1825±558	1355±489**	2109±710
Protein(g)	69±21	72±21	72±22	62±21	44±19**	72±21
Fat(g)	88±36	87±37	89±31	76±37	58±29*	89±33
Carbohydrate(g)	330±113	407±174	384±132	327±101	249±91*	427±157
ESC(%)	56.6±10.9	61.3±11.5	58.7±9.1	61.4±10.8	63.3±12.6	62.6±7.3
Food groups						
Rice(g)	494±187	486±157	471±183	395±177	243±173**	509±175
Meats(g)	119±90	99±76	98±77	74±73	45±49**	92±69
Drinks(g)	300±213	401±310	393±389	373±298	372±266	288±280

ESC: Energy supplies from carbohydrate. Values are means±S.D. Significant differences from 7-weeks-before values(*p<0.05, **p<0.01).

Table 6 Results in the competition.

Weight reduction rate	1st	2nd	3rd	4th	Best 8	Others
≧6%(n=6)	0	0	1	0	2	3
3≦and<6%(n=8)	2	0	1	0	1	4
<3%(n=8)	2	0	1	0	1	4

advantageous in terms of preparation.

Lastly, another change observed was an increase in FFA before matches. FFA are intermediates produced when triglycerides are converted to energy and they increase after sudden or heavy exercise. Blood was collected in the early morning before training, so this marked increase may be associated with weight loss itself. Thus, the degree of increase in FFA was more prominent in subjects with a moderate or marked weight reduction.

As expected, Hb decreased significantly 4 days before matches for an increase in Hb during weight loss is unlikely. Ht, the most sensitive parameter of blood concentration, did not change significantly, however, during weight loss. No previous study has reported this discrepancy, and the cause is unknown.

These marked changes in blood parameters appeared 4 days before matches. It was necessary for subjects to lose 1.5 kg more within the remaining 4 days, so blood parameters immediately before matches may have been even poorer.

Physical strength

Grip decreased significantly on the right side 4 days before matches in the marked weight reduction group. Grip is important in judo, and its decrease due to weight loss is disadvantageous. No significant changes were observed in other parameters measured, suggesting that decreased performance due to weight loss is low in overall muscle strength.

Nutrients and food intake

Most nutrients and food intakes markedly decreased before matches. Food intake in particular during the week preceding matches was about 60% of that before weight loss. As expected, these trends were prominent in the marked weight reduction group because severe dietary restriction could result in decreased LBM and a marked change in blood test values. Carbohydrates intake increased slightly, suggesting deliberate glycogen loading in some subjects. Most subjects, however, appear to have lost weight by decreasing general food intake.

Comparison with other studies

Scott et al.[5] evaluated the physiological effects of weight reduction (about 5% of body weight within 36 hours) in 7 college wrestlers and reported decreased muscle strength, aerobic power and anaerobic power. In our study, anaerobic power did not change, and no significant changes were observed in muscle strength except grip. Scott et al. did not note any decrease in body fat ratio, but did observe a decrease in LBM after weight loss. In our study, LBM also decreased, but the degree of decrease in body fat ratio was more marked. This may be due to the greater weight loss in the shorter term of their study involved a high biological burden.

Houston[4] evaluated the physiological effects of weight reduction (≧8% of body weight) in 4 days in college wrestlers and reported a gradual decrease in muscle strength during and after weight loss but no changes in aerobic or anaerobic powers. Unlike weight loss by rapid dehydration in Scott's study, they reduced weight by dietary and drinking restrictions with less demanding training. Our findings also differ from theirs in that no parameter except grip decreased, perhaps due to the greater weight loss in Houston's study (8% of body weight) than in ours (3.5%).

In our study, marked changes in blood test values were found during weight loss. These changes were noted in the marked weight reduction group. CK increased before matches in the slight and moderate weight reduction groups, but the marked weight reduction group showed no changes in CK, indicating inadequate practice due to excessive weight loss. Muscle strength (grip), nutrients and food intake decreased significantly before matches as the trend found in the marked weight reduction group. Our findings thus show that weight loss at WRR≧6% adversely affects the performance and health of the judoist.

Finally, as for results of all subjects in this judo competition, in the moderate and slight weight reduction groups, two subjects respectively have taken championship. However, in the marked weight reduction group, all 6 subjects could not reach the final match. It is very difficult to clarify the relationship between degree of weight reduction and result in judo competition because of confounding factors. However, in the marked weight reduction group, excessive weight reduction might have decreased their performance.

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