Gender Differences in Physical and Psychological Stress Responses among College Judoists Undergoing Weight Reduction

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Abstract

Gender-related differences in anthropometry, blood biochemistry, psychological parameters, and energy intake during prematch weight reduction were studied in 22 men and 7 women college judoists who lost weight by combining judo training, restricting food and fluid, and sweating. Body weight (BW) decreased significantly by 2.2 ± 1.4 kg in men and 2.0 ± 1.4 kg in women 2 weeks after weight reduction started — not significantly different. Body fat, relative body fat and total energy intake also decreased significantly in both groups 2 weeks after weight reduction started. Lean body mass decreased significantly 2 weeks after weight reduction started only in men. Men had significantly decreased blood lipids, immunoglobulins, complements, hematocrit, white blood cell count, and serum electrolytes, and significant increases in blood uric nitrogen, creatinine, and hemoglobin, while women showed no such changes. The score for vigor in the Profile of Mood States (POMS) decreased in both groups 2 weeks after weight reduction started, but with no statistically gender difference. In women, scores for anxiety in the State-Trait Anxiety Inventory (STAI) and confusion in POMS increased significantly. Although the men and women had the same BW reduction, significant physical stress response was seen only in men, and psychological stress due to weight reduction and mental pressure of an upcoming competition were seen more in women.

Key words: anthropometry, blood biochemistry, gender-stress differences, judoists, psychological parameters, weight reduction

Introduction

Many athletes lost weight to take part in athletic competition classed by weight. Ideally, athletes should reduce body fat without decreasing skeletal musculature¹⁾. Athletes usually try to reduce body weight (BW) by combining reduced food and fluid intake and exercise-induced sweating¹⁾. Previous studies suggest that such weight reduction decreases muscular strength, anaerobic capacity, and serum electrolytes, accelerating protein catabolism and inducing a thermoregulation disorder²⁻⁴⁾. Hroswill et al. also suggest weight reduction adversely affects the athletes' psychological conditions⁵⁾.

It was speculated that male and female athletes have different physical and psychological stress response, even if the same

weight reduction is made the same way in both. Virtually no information is available on gender differences in physical and psychological stress response during weight reduction in judoists. How weight reduction affects women judoist athletes has apparently not been studied, probably because women's judo was only officially adopted in the 1992 Olympic Games and has a relatively short history as an international sporting event.

We studied such differences in anthropometry, blood biochemistry, psychological parameters, and energy intake in 22 men and 7 women college judoists.

Methods

1. Subjects and study protocol

The subjects were 22 men and 7 women Japanese college judoists aged 18-22 years. Men took part in the All Japan Men's Judo Championship in Physical Education and Universities in March 1994; women took part in the Tokyo Women's College Judo Championship Classed by Weight in May 1995. Since all subjects start weight reduction on day 20 before the competition

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(questionnaire), their physical and psychological conditions were studied from day 20 before the competition and data from these first studies were analyzed as preweight reduction findings. Since conducting such studies just before competition was considered to strongly affect the subjects' physical and psychological conditions, a second study was made on day 4 before the competition in men and day 5 in women. Data from the second study was analyzed as the last weight reduction period findings. Results of the questionnaire indicated that subjects lost weight by combining judo training, reduced food and fluid intake, and sweating, widely used by athletes in weight-based events¹⁾. Study protocol and purpose were explained to subjects, who then agreed to take part.

2. Anthropometry

Anthropometric changes were calculated from BW, lean body mass (LBM), body fat (BF) and relative body fat (%fat). BW to be lost to enter a weight category was calculated from BW of individual athletes before weight reduction. Body density was measured by underwater weighing and %fat was calculated from measured body density using Brozek's equation⁶⁾. Residual lung volume was measured by oxygen rebreathing nitrogen dilution⁷⁾.

3. Blood biochemistry

Total protein (TC), albumin (Alb), glucose (Glu), triglyceride (TG), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), apoprotein A-I (Apo A-I), apoprotein A-II (Apo A-II) and apoprotein B (Apo B) were used as nutritional markers in serum. Changes in glutamic oxaloacetic transaminase (GOT), glutamic pyruvic transaminase (GPT), lactate dehydrogenase (LDH) and creatine kinase (CK) were used to calculate the condition of muscle activity, muscle damage and hepatic function. Concentrations of immunoglobulins (IgG, IgA and IgM), complements (C3 and C4) and white blood cells count (WBC) were used to evaluate immunological function. Uric acid (UA), blood uric nitrogen (BUN) and creatinine (Cr) were used to observe renal function. Hemoglobin (Hb), Hematocrit (Hct), Fe and serum electrolytes (Ca, Na, K, Cl) were used to calculate anemia and dehydration. Venous blood samples (10ml) were collected from the forearm vein of seated subjects after overnight fasting, centrifuged, and stored in -80 °C until a blood biochemistry analysis was done. Hb, Hct and WBC were analyzed using an automatic cell counter (Coulter Micro Biff II, Coulter Co., Ltd., USA). Other blood biochemistry assays were as follows: TP by biuret; Alb by bromocresol green; TC, TG,

and Glu by enzymatic analysis; HDL-C by dextran-magnesium chloride; apoproteins and immunoglobulins by turbidimetric immunoassay; GOT, GPT, LDH and CK by ultraviolet (UV) analysis, UA by uricase enzyme; BUN by urease-UV; Cr by Jaffe's method; Fe by ferrosime; Ca by orthocresolphthalein complexone; Na by glass electrode; K by valinomycin electrode; and Cl by AgCl electrode.

4. Psychological parameters

Psychological changes during weight reduction were evaluated based on the profile of mood states (POMS)⁸⁾ and state and trait anxiety inventory (STAI)⁹⁾. POMS assessed changes in tension, anger, confusion, vigor, depression, and fatigue¹⁰⁾. STAI assessed changes in state and trait anxiety⁹⁾.

5. Dietary intake

Total energy intake (TEI) was calculated from the subjects' descriptions in the nutritional questionnaire as a diary where subjects entered daily food and fluid intake during weight reduction. The mean TEI for 3 days before the first and second studies was calculated.

6. Statistics

The statistical significance of differences in the values between the preweight reduction period and the last weight reduction period was tested by the paired t-test. The generalized Wilcoxon test was used to determine significant mean differences between men and women. A two-sided p of less than 0.05 was considered statistically significant. All calculation was by the Statistical Analysis System¹¹⁾.

Results

Subjects and anthropometry are summarized in Table 1. Mean BW reduction required for competition was 3.7 ± 2.2 kg in men and 3.1 ± 1.7 kg in women, and these values were not significantly different from each other. BW was significantly reduced by 2.2 ± 1.4 kg in men and 2.0 ± 1.4 kg in women after 2-weeks of weight reduction, but these values were also not significantly different from each other. BF, %fat and TEI decreased significantly in both men and women after weight reduction. TEI change after weight reduction in women was significantly less than in men. A significant decrease in LBM after weight reduction was seen only in men. BF and %fat before weight reduction in men were significantly ($p < 0.01$) lower than

Table 1 Characteristics of study subjects and changes in anthropometric parameters and total energy intake during weight reduction.

Parameters	Men (n=22)		Women (n=7)	
	Pre	Post	Pre	Post
Age (year)	20.1 ± 0.9	—	19.9 ± 1.9	—
Height (cm)	172.4 ± 7.0	—	161.7 ± 4.5	—
Body weight reduction required for competition (kg)	3.7 ± 2.2	—	3.1 ± 1.7	—
Body weight (kg)	78.7 ± 11.2	76.5 ± 11.5**	60.9 ± 7.5	58.9 ± 7.5**
Lean body mass(kg)	69.6 ± 7.9	68.5 ± 8.2**	50.7 ± 4.9	49.6 ± 5.0
Body fat (kg)	9.1 ± 4.7	7.9 ± 4.1**	9.8 ± 3.4	8.8 ± 3.0**
Relative body fat (%)	11.1 ± 4.5	10.1 ± 4.5**	15.9 ± 4.6	14.9 ± 4.4*
Total energy intake (kcal)	1885 ± 638	921 ± 335**	2291 ± 708	1970 ± 448*†

Results were expressed as mean ± standard deviation.

Pre: pre-weight reduction findings. Post: post-weight reduction findings.

*: $p < 0.05$, **: $p < 0.01$, Significantly different from the values before weight reduction in each gender.

†: $p < 0.05$, ††: $p < 0.01$, Significant differences in the changes between men and women during weight reduction.

in women.

Changes in blood biochemistry during weight reduction are summarized in Table 2. Only men showed significant changes, i.e., lipids, WBC, immunoglobulins, complements, and Hct decreased significantly, while BUN, Cr, and Hb increased after weight reduction but not in women. Significant changes in serum electrolytes were seen only in men.

Table 3 shows changes in psychological parameters during

weight reduction. The score for vigor in POMS was significantly decreased in men. In women, scores for the state anxiety inventory in STAI and for confusion in POMS increased significantly. Decreased vigor in POMS in women was about the same as in men. Scores for anger and confusion in POMS before weight reduction differed significantly ($p < 0.05$) between men and women.

Table 2 Changes in blood biochemical parameters during weight reduction.

Parameters	Men (n=22)		Women (n=7)	
	Pre	Post	Pre	Post
Total protein (g/dl)	7.6 ± 0.3	7.5 ± 0.5	7.0 ± 0.5	6.9 ± 0.5
Albumin (g/dl)	4.9 ± 0.4	5.0 ± 0.3	4.3 ± 0.3	4.2 ± 0.3
Glucose (mg/dl)	89.4 ± 8.1	85.6 ± 6.5	85.5 ± 10.3	85.3 ± 2.8
Triglyceride (mg/dl)	138.7 ± 87.3	87.7 ± 36.1*	78.4 ± 26.1	83.4 ± 17.4††
Total cholesterol (mg/dl)	168 ± 23	162 ± 27	181 ± 26	166 ± 25
HDL-cholesterol (mg/dl)	57.7 ± 11.7	57.0 ± 10.0	71.6 ± 19.6	62.0 ± 16.1
Apoprotein A-I (mg/dl)	158 ± 21	141 ± 15**	163 ± 34	146 ± 22
Apoprotein A-II (mg/dl)	35.8 ± 5.0	31.5 ± 2.9**	34.8 ± 5.7	34.4 ± 3.3
Apoprotein B (mg/dl)	88.8 ± 16.8	80.1 ± 15.0*	82.6 ± 28.2	70.0 ± 17.9
GOT (U/l)	25.7 ± 6.1	24.5 ± 5.1	23.9 ± 6.2	21.4 ± 4.1
GPT (U/l)	17.4 ± 5.2	12.0 ± 5.0**	16.7 ± 6.4	12.5 ± 4.1
LDH (U/l)	180.7 ± 36.0	169.6 ± 30.7	188.2 ± 25.9	185.6 ± 33.1
CK (U/l)	356 ± 231	407 ± 190	161 ± 71	163 ± 61
Uric acid (mg/dl)	6.0 ± 1.1	6.4 ± 1.3	3.7 ± 0.7	4.0 ± 0.6
BUN (mg/dl)	16.0 ± 2.9	18.0 ± 2.9*	15.2 ± 3.6	14.3 ± 3.7
Creatinine (mg/dl)	1.0 ± 0.1	1.1 ± 0.1**	0.9 ± 0.1	0.8 ± 0.1††
IgG (mg/dl)	1275 ± 158	1271 ± 190	1235 ± 209	1209 ± 258
IgA (mg/dl)	240 ± 102	226 ± 92	185 ± 56	224 ± 70†
IgM (mg/dl)	127 ± 34	110 ± 35**	155 ± 41	172 ± 47
C3 (mg/dl)	105 ± 13	94 ± 13**	102 ± 8	101 ± 13
C4 (mg/dl)	27.5 ± 5.5	24.5 ± 6.3**	27.8 ± 4.7	26.1 ± 4.7
WBC (/μl)	7659 ± 1246	6419 ± 1246**	6643 ± 1453	6636 ± 1465
Hemoglobin (g/dl)	15.6 ± 0.8	18.0 ± 1.4**	13.6 ± 0.9	14.0 ± 1.2††
Hematocrit (%)	47.4 ± 2.0	44.6 ± 5.8*	39.5 ± 8.0	39.2 ± 8.0
Fe (ug/dl)	94.2 ± 34.6	102.3 ± 31.3	60.7 ± 24.4	76.1 ± 47.6
Ca (mg/dl)	9.8 ± 0.4	9.7 ± 0.2	9.4 ± 0.4	9.2 ± 0.3
Na (mEq/l)	143.6 ± 1.6	144.6 ± 1.5*	140.1 ± 2.7	140.1 ± 1.8
K (mEq/l)	4.6 ± 0.3	4.4 ± 0.2**	4.2 ± 0.2	4.3 ± 0.3
Cl (mEq/l)	105.8 ± 1.5	107.4 ± 1.4**	106.4 ± 0.9	105.9 ± 1.4

Results were expressed as mean ± standard deviation.

Pre: pre-weight reduction findings. Post: post-weight reduction findings. HDL-cholesterol: high-density-lipoprotein cholesterol. GOT: glutamic-oxaloacetic transaminase. GPT: glutamic-pyruvic transaminase. LDH: lactate dehydrogenase. CK: creatine kinase. BUN: blood uric nitrogen.

WBC: white blood cell count.

*: $p < 0.05$, **: $p < 0.01$, Significantly different from the value before weight reduction in each gender.

†: $p < 0.05$, ††: $p < 0.01$, Significant differences in the changes between men and women during weight reduction.

Table 3 Changes in psychological parameters during weight reduction.

Parameters	Men (n=22)		Women (n=7)	
	Pre	Post	Pre	Post
STAI				
X-I	35.4 ± 6.3	36.1 ± 7.2	38.8 ± 8.3	45.4 ± 8.3*
X-II	38.2 ± 4.5	39.2 ± 5.3	46.4 ± 10.2	43.0 ± 8.5
POMS				
Anger	10.0 ± 8.3	7.5 ± 5.4	4.7 ± 4.6	5.6 ± 4.2
Confusion	8.1 ± 3.3	8.3 ± 4.1	4.1 ± 2.7	6.7 ± 3.1*
Depression	8.7 ± 7.7	7.7 ± 7.6	4.3 ± 5.0	4.1 ± 2.7
Fatigue	6.2 ± 3.9	7.2 ± 4.2	6.4 ± 6.0	5.1 ± 4.1
Tension	10.2 ± 5.3	10.8 ± 4.4	7.9 ± 4.8	8.9 ± 4.8
Vigor	13.7 ± 5.6	11.5 ± 5.2*	14.9 ± 6.3	10.9 ± 6.7

Results were expressed as mean ± standard deviation.

Pre: pre-weight reduction findings. Post: post-weight reduction findings.

STAI: State Trait Anxiety Inventory. X-I: state of anxiety. X-II: trait of anxiety. POMS: Profile of Mood States.

*: $p < 0.05$, **: $p < 0.01$, Significantly different from the value before weight reduction in each gender.

Discussion

There was no difference in the weight reduction value (2.2 ± 1.4 kg and 2.0 ± 1.4 kg in men and women) and the rate ($2.8 \pm 1.9\%$ and $3.1 \pm 2.3\%$ in men and women) between men and women in this study, and, finally, all members among the men and women could get to their target weights. Though BF and %fat decreased significantly in both men and women in the last weight reduction period, a significant decrease in LBM was seen only in men. Therefore, women may have more ideal weight reduction than men, perhaps due to gender anthropometric differences of BF and %fat tending to be lower in men than women. This gender difference may make it harder for men to lose weight.

Significant changes in blood biochemistry were seen only in men. Previous studies reported that exercise and dietary restriction improved lipid metabolism^{12,13}. Our men seem to have been strongly influenced by exercise and more severe in dietary restriction during weight reduction, so we cannot rule out the possibility of marasmus and triglyceride production disorder due to dystrophic changes¹⁴.

BUN and Cr increased only in men, suggesting that men probably had renal dysfunction due to weight reduction¹⁵. Energy restriction also appeared to accelerate protein catabolism in men¹⁶.

To our knowledge, no study deals with the effects of weight reduction on immune responses in judoists, and previous studies findings are fuzzy about exercise and immune responses. WBC, immunoglobulins, and complements decreased significantly only in men. Leukocytes increases induced by acute exercise have previously been reported by many investigators¹⁷. Immunoglobulins, however, have been reported either unchanged¹⁸ or affected¹⁹ by exercise. Similarly, complements were reported unchanged²⁰, decreased¹⁸, or increased²¹ by exercise. Catchatourian et al. suggested that moderately severe protein deprivation significantly impairs leukocyte function²², and Kelley et al. showed that restricting energy significantly decreases serum concentrations of immunoglobulins and complements²³. Although we cannot specify which weight reduction method — judo training, reduced food and fluid intake, or sweating — affected immunological parameters, our results suggest that immunocompetence deteriorated during weight reduction.

Many studies have shown that weight reduction by restricting fluids induces dehydration and greater serum electrolyte loss²⁴. In our study, signs of dehydration were changes in Hb and serum electrolytes, seen only in men; the most

sensitive dehydration index, Hct, paradoxically decreased in the last period weight reduction in our subjects. Dietary protein restriction reportedly decrease the circulating red cell volume²⁵, decreasing iron binding capacity and causing anemia²⁶. Other studies suggested that exercise causes hemolytic anemia²⁷ and increases osmotic red cell fragility²⁸. Although these previous findings may partially explain the above paradoxical Hct decrease, further study is needed to understand hematic changes associated with dehydration. Conceivably, exercise, dietary restriction, or dehydration may cause abnormalities in red cell membranes leading to hemolysis. Although, hematological parameters should be corrected for hemoconcentration in dehydration, we did not do so because we thought our subjects were influenced by dehydration, exercise, and dietary restriction, and the amount of serum components in parameters may be changed by weight reduction.

As mentioned, Horswill et al. studied changes in POMS during weight reduction and suggested that weight reduction adversely affected the subjects' psychological conditions⁵. Raglin et al. studied changes in POMS in men and women athletes and found that exercise induces gender differences in psychological conditions²⁹, although other studies showed no such differences between men and women athletes³⁰. In our study, though the physiological stress of weight reduction in men was stronger than that in women, the changes in score for the state anxiety inventory in STAI and confusion in POMS in women was greater than that in men. It is suggested that women judoists are easily affected by mental pressure from upcoming athletic competition or from weight reduction more than men judoists, because all members, both male and female, could reach to their target weights. But we could not determine whether psychological parameters were affected by mental pressure from an upcoming athletic competition or by weight reduction, because we did not provide controls such as those with no weight reduction or those not taking part in competition. It was suggested by our study that these gender differences in athletes during weight reduction should be further explored in relation to intrinsic physical and psychological characteristics of gender.

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Reference

- 1) Smith NJ, Stanitski CL. Sports medicine: A practical guide. Philadelphia: W.B. Saunders Company, 1986.
- 2) Oppliger AA, Case HS, Horswill CA, Landry GL, Shelter AC. American College of Sports Medicine position Stand, Weight loss in wrestlers. *Med Sci Sports Exer* 1996; 28(2): ix-xii.
- 3) Roemmich JN, Sinning WE. Weight loss and wrestling training: effects on nutrition, body composition, and strength. *J Appl Physiol* 1997; 82(6): 1751-9.
- 4) McMurray RG, Proctor WL. Effect of caloric deficit and dietary manipulation on aerobic and anaerobic exercise. *Int J Sports Med* 1991; 12: 167-72.
- 5) Horswill CA, Hickner RC, Scott JR, Costill DL, Gould D. Weight loss, dietary carbohydrate modifications, and high intensity, physical performance. *Med Sci Sports Exer* 1990; 22(4): 470-6.
- 6) Brozek J, Grande F, Anderson JT, Keys A. Densitometric analysis of body composition: revision of some quantitative assumption. *Ann NY Acad Sci* 1963; 100: 113-40.
- 7) Wilmore JH. A simplified method for determining residual

- lung volume. *J Appl Physiol* 1969; 27: 96-100.
- 8) McNair DM, Losr M, Droppleman LF. Profile of mood states manual. San Diego CA: Educational and Industrial Testing Service, 1971.
 - 9) Spielberger CD. Anxiety-current trends and theory. New York Academic Press, 1972.
 - 10) Raglin JS, Morgan WF. Development of scale for in monitoring training-induced distress in athlete. *Int J sports Med* 1994; 15(2): 84-8.
 - 11) SAS Institute, Inc. SAS/STAT user's guide, release 6.03 edition. Cary, NC; SAS Institute Inc, 1988.
 - 12) Merrill GF, Friedrichs GS. Plasma lipids concentrations in college students performing self-selected exercise. *J Am College Nutr* 1990; 9(3): 226-30.
 - 13) Wood PD, Stefanick ML, Williams PT, Haslell WL. The effects on plasma lipoproteins of prudent weight-reducing diet, with or without exercise, in overweight men and women. *N Engl J Med* 1991; 325(7): 461-6.
 - 14) Streja DA, Marliss EB, Steiner G. The effects of prolonged fasting on plasma triglyceride kinetics in men. *Metabolism* 1977; 26(5): 505-16.
 - 15) Radigan LR, Robinson S. Effect of environmental heart stress and exercise on renal blood flow and filtration ratio. *J Appl Physiol* 1949; 2: 185-91.
 - 16) Runcie J, Thomson TJ. Prolonged starvation--a dangerous procedure?. *Br Med J* 1970; 3(720): 432-5.
 - 17) Nielsen HB, Secher NH, Kappel M, Pedersen BK. Lymphocyte, NK, LAK cell response to maximal exercise. *Int J Sports Med* 1996; 17(1): 60-5.
 - 18) Nieman DC, Tan SA, Lee W, Berk LS. Complement and immunoglobulin levels in athlete and sedentary controls. *Int J Sports Med* 1989; 10: 124-8.
 - 19) MacKinnon LT, Jenkins DG. Decreased salivary immunoglobulins after intense interval exercise before and after training. *Med Sci Sports Med* 1993; 25(6): 678-83.
 - 20) Thomsen BS, Rodgaard A, Tvede N, Hansen FR, Steensberg J, Halkjaer Kristensen J, Pedersen BK. Levels of complement receptor type one (CR1, CD35) on erythrocytes, circulating immune complexes and complement C3 split products C3d and C3c are not changed by short-term physical exercise or training. *Int J Sports Med* 1992; 13(2): 172-5.
 - 21) Dufaux B, Order U, Liesen H. Effect of short maximal physical exercise on coagulation, fibrinolysis, and complement system. *Int J Sports Med* 1991; 12: S38-42.
 - 22) Catchatourian R, Eckerling G, Fried W. Effect of short-term protein deprivation on hemopoietic functions of healthy volunteers. *Blood* 1980; 55(4): 625-8.
 - 23) Killey DS, Daudu PA, Branch LB, Johnson HL, Taylor PC, Mackey B. Energy restriction decreases number of circulating natural killer cells and serum levels of immunoglobulins in overweight women. *Eur J Clin Nutr* 1994; 48(1): 9-18.
 - 24) Costill DL, Sparks KE. Rapid fluid replacement following thermal dehydration. *J Appl Physiol* 1973; 34(3): 299-303.
 - 25) Rooth G, Carlstrom S. Therapeutic fasting. *Acta Med Scand* 1970; 187(6): 455-63.
 - 26) Katunguka-Rwakishaya E, McKechnie D, Parkins JJ, Murray M, Holmes PH. The influence of dietary protein on live bodyweight, degree of anaemia and erythropoietic responses of Scottish blackface sheep infected experimentally with *Trypanosoma congolense*. *Research in Veterinary Science* 1997; 63(3): 273-7.
 - 27) Streeton JA. Traumatic haemoglobinuria caused by karate exercises. *Lancet* 1967; 2(7508): 191-2.
 - 28) Sagawa S, Shiraki K. Role of lipids in stabilizing red cells in rats. *J Nutr Vitaminol* 1978; 24(1): 57-65.
 - 29) Raglin JS, Morgan WP, O'Connor PJ. Changes in mood states during training in female and male college swimmers. *Int J Sports Med* 1991; 12(6): 585-9.
 - 30) Speechly DP, Taylor SR, Rogers GG. Differences in ultra-endurance exercise in Performance-matched male and female runners. *Med Sci Sports Exer* 1996; 28(3): 359-65.