Food Restriction, Performance, Psychological State and Lipid Values in Judo Athletes

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Dietary intake, plasma lipids, lipoprotein and apolipoprotein levels, anthropometric measurements and anaerobic performance were studied in eleven judo athletes during a period of weight maintenance (T_1) and after a 7d food restriction (T_2). Dietary data were collected using a 7-day diet record. Nutrient analysis indicated that these athletes followed a low carbohydrate diet whatever the period of the investigation. Moreover, mean micronutrient intakes were below the French recommendations. Food restriction resulted in significant decreases in body weight. In addition, it had significant influence on triglyceride and free fatty acid, although glycerol, total cholesterol, LDL-C, HDL-C, apolipoprotein A-1 and B did not alter. Left arm strength and 30 s jumping test decreased significantly. The 7 s jumping test was not affected by the food restriction. Regardless of psychological parameters, tension, anger, fatigue and confusion were significantly elevated from T_1 to T_2; vigor was significantly lower. The data indicated that a 7-day food restriction adversely affects the physiology and psychology of judo athletes and impairs physical performance, possibly due to inadequate carbohydrate and micronutrients.

Key words: Diet, performance, lipid profile, psychological state, judo.

Introduction

Competitions in wrestling or boxing are contested in weight classes, and most athletes compete in a class 5–10% below their usual weight [8]. Dietary studies have indicated that there is extreme variability in the dietary regimes looking for the optimum athletic diet. Little information is available on judo athletes. Nevertheless, it is known that they typically lose weight rapidly before competitions by a reduction in food intake, sweating through intensive exercise in plastic suits to promote water loss, fluid restrictions and even the use of diuretics. However, such body weight reduction may affect plasma and blood volume [3], endocrine function [8], induce a physiological and a psychological stress [22,44] and have immediate effects on sports performance on aerobic endurance capacity [14,49]. Effects on anaerobic performance is more controversial [14]. Weight reduction may also lead to alterations in lipid and lipoprotein profile with a reduction of total cholesterol (TC), LDL-C and an increase of HDL-C [50,27]. Nevertheless, these alterations depend on the type of weight loss (gradual or rapid weight loss) [27,33] of the sport practised (aerobic versus anaerobic) [9,15,27,39], of the intensity of the exercise [34] and of the type of diet (i.e, high fat or high carbohydrate diet) [7]. However, the data are controversial [2,28].

The purpose of this study was to investigate the influence of 7-d food restriction on physical performance, plasma lipids, lipoproteins and apolipoproteins, and psychological profile in a group of elite male judo athletes preparing for a national championship, a sport that requires both glycolytic energy production, and an adequate aerobic reserve to sustain activity over the five-minute match duration [41]. In order to evaluate the food restriction, a 7d food record was used during a period of weight maintenance and after a 7d food restriction.

Methods

Eleven athletes from the Auvergne League were assessed two months and one day before a major national competition. Physical characteristics of the subjects are presented in Table **1**.

Their mean period of practising this sport was 10 ± 3.2 years. All participated in six to nine hours of training per week and had competitive experience in regional and national tournaments. One had competed internationally. Their technical level ranged between 2nd and 3rd Dan black belt. All the sportsmen fought in a category less than 73 kilograms. Subjects signed a letter of informed consent after being informed of the risks involved. They were not taking any drugs or medication and had no history or endocrine disorders before or during this study. They were not taking any supplements.

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Table 1 Anthropometric parameters measured during a weight maintenance period (T_1) and after a 7d food restriction (T_2) (Mean ± SD)

	BW (kg)	Height (cm)	% Body fat	BMI (kg × m^{-2})	FFM (kg)
T_1	75.1 ± 2.6	172.9 ± 1.5	17.3 ± 2.1	24.9 ± 1.2	62.1 ± 2.2
T_2	71.5 ±1.3*		16.8 ± 1.4	23.1 ± 0.7*	59.8 ± 2.7
Change (%)	–4.9 ± 1.2		–1.8 ± 1.8	–6.8 ± 1.1	–3.7 ± 2.1

N = 11, $^*P < 0.05$ (T_2 vs T_1)

Assessments (weight, performance, psychological test, nutritional status, blood samples) were made during a period of weight maintenance (T_1) and after a 7d food restriction (T_2), one day before a national championship. The period of weight maintenance was considered a baseline phase and judo athletes performed their regular regimens of judo and interval and resistance training. Judo training sessions were normally 2 h in duration, consisted of judo specific skills and drills and randori (fighting practice).

Body composition

At T_1 and T_2, the weight and height of each subject were measured and the percentage of body fat mass was estimated from four measurements of skinfold thickness according to Durnin and Rahaman [10]. A Harpenden caliper was used to measure the thicknesses, i.e., biceps, triceps, subscapular and suprailiac on the right side of the body with the subject in a standing position. Weight was measured on a digital scale with an accuracy of 0.1 kg.

Dietary intake

Values for nutrient intakes were obtained from a 7d food record kept during a period of weight maintenance and after a 7d food restriction. The diet for food restriction was self-selected. All participants received a detailed verbal explanation and written instructions. Subjects were asked to eat normally and to remain as close as possible to their usual dietary habits during the period of diet recording and to be as accurate as possible in recording the amount and type of food and fluid consumed. They were asked to record brand names of all commercial and ready-to-eat foods consumed and method of preparation. A list of common household measures, such as cups and tablespoons, and specific information about the quantity in each measurement (grams, etc.) was given to each participant. Any questions, ambiguities, or omissions regarding the type and amount of food and beverages consumed were resolved with individual judo athletes and controls via direct interviews. A color photo exhibit [40] of commonly consumed foods and their portion sizes was used during the interview to assist in estimating amounts consumed. Daily energy and nutrient intakes were calculated by a computer program developed by SCDA Nutrisoft (Bilnut.4 software package, France). This diet analysis program accesses French nutrient data base for standard reference [11].

Physical performance measures

In order to evaluate the performance of each subject, we chose specific tests of this sport, which seemed to be adequate to represent aspects of physical fitness in judo [41]. This performance was done 30 min after anthropometric assessment. The order of the tests was always 1) static strength and 2) vertical jump.

Muscular strength measures included right and left-grip strength (Harpenden dynamometer, British Indicators, Ltd.). The strength score, recorded in kilograms, was the average of two trials.

Vertical jumping height was determined on a platform [4] which was connected to a digital timer. The test battery consisted of vertical jumps performed from a standing position 1) without a preliminary counter movement jump, squat-jump (SJ), 2) with a preliminary counter movement jump (CMJ).

The mechanical power of the lower limb extensor musculature was measured in a jumping test. The subjects performed successive maximal jumps (CMJ) on the platform during a period of 1) 7 s and 2) 30 s keeping their hand on their hips. The cumulative flight time and the number of jumps performed formed the basis for the calculations of mechanical power [5].

Blood collection and biochemical analysis

After their full informed consent, experiments were conducted in accordance with general ethical rules. Blood samples (5 ml) were drawn from the antecubital vein into plain vacutainer tubes using EDTA (1 mg × 1 ml^{-1}) as anticoagulant after a twelve-hour overnight fast, and at least twenty-six hours after the last training session. The proportion of cholesterol, and triglycerides (TG) and phospholipids was analysed by enzymatic techniques in HITACHI 911 (Roche Diagnostics) according to the manufacturer's protocol. The HDL fraction of cholesterol was measured after precipitation of VLDL and LDL by phosphatic acid. The fraction related to the LDL was precipitated by BIOMERIEUX reagent.

The apolipoproteins A1 and B were measured using DADE-BEHRING Turbiquant reagents by immunoturbidimetry methods.

The FFA were determined with enzymatic reaction using acetyl-CoA synthetase and acetyl-CoA oxydase produced for Wako Laboratories.

Glycerol was phosphorylated by glycerol kinase and ADP. The ADP was reconverted into ATP by PEP with the aid of pyruvate kinase with the protocol edited for Boehringer.

Psychological measurements

The profile of the mood states (POMS) [29] was used to assess changes in tension, anger, confusion, vigor, depression, and fatigue during weight loss.

Statistical method

Anthropometric data, physical performance and psychological parameters are expressed as a mean and standard deviation. Lipid values and nutrient intake are presented as mean ± SE. We used the nonparametric Wilcoxon's test to test differences within a procedure (T_1 vs T_2). The SPSS/PC statistical package was used and the criterion for significance was set at $P < 0.05$.

Results

Table **1** shows the mean values (± SD) of height, body weight (BW), body mass index (BMI), fat free mass (FFM) and the % of body fat obtained during a weight maintenance period (T_1) and after a 7d food restriction (T_2), together with percentages changes pre to post weight loss. The weight-loss period resulted in significant decreases in BW ($P < 0.05$), BMI ($P < 0.05$). FFM had a tendency to decrease.

Mean (± SE) physical performance are presented in Fig. **1**. We noted a significant decrease of left hand grip values (LHG) at T_2 compared to those observed at T_1 ($P < 0.05$) although no differences appeared in right hand grip (RHG). Simple Jump (SJ) or counter movement jump (CMJ) were not influenced by a period of food restriction. Weight reduction did not affect total work output during the 7-s test but induced a decrease during the 30 s test ($P < 0.05$) (Fig. **1**).

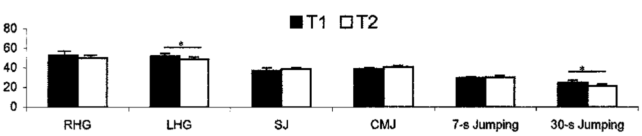

Fig. 1 Right (RHG) and left hand grip (LHG) (kg), simple (SJ) and counter movement jump (CMJ) (cm), 7 s and 30 s jumping tests ($W \times kg^{-1}$) measured before (T_1) and after a 7d food restriction (T_2) (Mean ± SD) *: $P < 0.05$ (T_2 vs T_1).

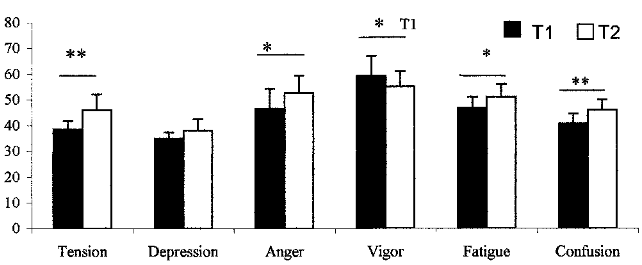

Fig. 2 Profile of mood states at T_1 and T_2.

The mood states of confusion, anger, fatigue and tension were significantly higher after weight loss (Fig. **2**). Vigor was significantly lower after the period of food restriction ($P < 0.05$).

Serum lipid, lipoprotein and apolipoprotein levels are shown in Table **2**. No significant differences were observed in serum total cholesterol (TC), phospholipids (Ph-lipids), glycerol, LDL-C, HDL-C, apolipoprotein B (Apo-B), and A-1 (Apo-A1). However, the level of triglycerides and free fatty acid (FFA) were significantly higher at T_2 ($P < 0.05$).

Table **3** shows dietary intake at baseline (weight maintenance T_1) and after the 7d food restriction. Compared with baseline, energy intake was significantly ($P < 0.01$) lower during weight reduction procedure. The proportion of total calories from carbohydrates was low compared to French recommendations [19] whatever the period of investigation. Excluding thiamin, and vitamin A and E, micronutrient intakes during weight reduction were lower ($P < 0.01$) than during baseline [T_1]. All mean micronutrient intakes were below the respective recommendation [18] whatever the period of this investigation (Table **4**).

Discussion

The objective of this investigation was to determine whether the physiology and psychology of judo athletes who lose weight after a 7d food restriction as well as their physical performance is affected. The main results were the decrease in anaerobic performance, the modification in psychological profile and the increase of TG and FFA.

Food records, as used in this study, are considered the standard for dietary assessment and provide a quantitative account of an individual's diet during a specific period. Although the judo athletes in this study were highly motivated, underreporting errors may have occurred. Therefore, it is important to view the report data as the mean intake for these athletes. Baseline energy intake (T_1) was average for athletes practising high intensity weight loss sports but low compared with 3000–4800 $kcal \times d^{-1}$ reported for male endurance athletes [13]. The average caloric intake during the food restriction period was 2107 ± 179.4 $kcal \times d^{-1}$, which induced a decrease of body weight (4.9 + 1.2 %), which was in accordance with other athletes practising weight loss sports [35]. The loss of body weight represented an average of 3.6 kg in absolute (Table **1**). The deficit in energy intake represented about 1000 kcal per day, i.e. 7000 kcal for a week. This corresponded to less than 1 kg of body fat. So, the main part of the body weight loss was body water loss. We reported that the proportion of total calories from carbohydrates was low compared to French recommendations [19] whatever the period of the investigation. In a

Table 2 Serum lipid, lipoprotein and apolipoprotein levels of judo athletes. For comparison, reference range for adults were listed (Mean ± SD)

	TC $mmol \times l^{-1}$	TG $mmol \times l^{-1}$	Ph-lipid $mmol \times l^{-1}$	FFA $mmol \times l^{-1}$	Glycerol $mmol \times l^{-1}$	LDL-C $mmol \times l^{-1}$	HDL-C $mmol \times l^{-1}$	Apo $g \times l^{-1}$	Apo-A1 $g \times l^{-1}$	B/A1
T_1	4.50 ± 0.2	0.63 ± 0.06	2.50 ± 0.1	0.31 ± 0.05	0.17 ± 0.01	2.57 ± 0.2	1.15 ± 0.05	0.83 ± 0.05	1.04 ± 0.04	0.77 ± 0.06
T_2	4.58 ± 0.2	0.92 ± 0.08*	2.68 ± 0.1	0.53 ± 0.2*	0.12 ± 0.0	2.62 ± 0.2	1.09 ± 0.08	0.79 ± 0.04	1.04 ± 0.07	0.81 ± 0.08
Norm	3 - 6	0.5 - 1.6	2 - 3.2	0.1 - 0.5	0.05 - 0.2	2.9 - 4	0.75 - 1.6	0.45 - 1.2	1 - 1.8	

N = 11. *: $P < 0.05$ (T_2 vs T_1)

Table 3 Mean nutrient intake of judo athletes at T1 and T2 (Mean ± SD). For comparison, French norms for sportsmen are listed [19]

	T_1	T_2	French Norm
Energy intake (kcal × d⁻¹)	3029 ± 281.6	2101.7 ± 179.4** (30%)	3000 – 3500
Total protein (g × d⁻¹)	124.9 ± 16.2	88.3 ± 8.5* (29%)	81
Total Fat (g × d⁻¹)	118.2 ± 9.9	85.7 ± 8.5** (27%)	100
Carbohydrate (g × d⁻¹)	360.7 ± 52.2	236.5 ± 25.1	450
% Protein	16.3 ± 0.8	17.1 ± 0.9	15
% Fat	35.5 ± 3.0	37.4 ± 2.4	< 30
% Carbohydrate	48.0 ± 3.0	45.4 ± 2.8*	60
Water (g)	2684.7 ± 352.7	1915.7 ± 7.1** (28%)	3500
Cholesterol (mg)	493.7 ± 79.9	332.5 ± 32.9	350

N = 11. *: $P < 0.05$; **: $P < 0.01$ (T_2 vs T_1)

Table 4 Mean intake of micronutrients for judo athletes at T1 and T2 (Mean ± SD). For comparison, French norms are listed [19]

	T_1	T_2	French Norm
A (µg)	1500 ± 250.2	1449 ± 362.8	2000
E (mg)	9.5 ± 2.7	9.1 ± 1.9	30
Thiamin (mg)	1.5 ± 0.2	1.15 ± 0.1	5 – 10
Riboflavin (mg)	7.05 ± 0.6	3.6 ± 0.1** (49%)	12
B3 (mg)	18.1 ± 1.5	12.8 ± 1.2** (29%)	30
B6 (mg)	2.8 ± 0.3	1.8 ± 0.08 (38%)	20
B12 (µg)	12.9 ± 0.8	9.1 ± 0.7** (30%)	10 – 20
B5 (mg)	14.1 ± 0.5	9.8 ± 0.4** (35%)	20
Magnesium (mg)	396 ± 12.2	216.8 ± 15.6** (40%)	700
Potassium (g)	3.5 ± 0.7	2.2 ± 0.1 (36%)	5.25
Sodium (g)	4.2 ± 0.6	2.7 ± 0.1* (34%)	6.6

N = 11. *: $P < 0.05$; **: $P < 0.01$ (T_2 vs T_1)

hypoenergy diet, a relatively low (about $1 g \times kg^{-1} \times d^{-1}$) protein intake, such as in the present study, may be inadequate to maintain muscle protein [23]. Regarding carbohydrates, an intake $< 500 g \times d^{-1}$ may be too small to ensure rapid glycogen resynthesis after training sessions [25]. Although the amount of carbohydrates needed by judo athletes on a daily basis is not known, a low carbohydrate intake may impair recovery and increase loss of body protein and intracellular water [13]. We also noted that the micronutrient intakes were below the recommendations [19], whatever the period of this investigation. However, van Dale et al. [47] have reported that for athletes, good status of thiamin, riboflavin, B6, and magnesium (i.e., vitamin and mineral element needed as enzyme activators in muscle metabolism) are particularly important.

The effect of food restriction, especially of a low carbohydrate diet (45.4% of total calories as it is the case in our study), on anaerobic performance is unclear. To our knowledge, no data are available in judo. However, several studies investigated in wrestlers the effect of weight loss on performance tests that included muscle strength and arm or leg-Wingate tests, but the results are under debate [18,24,49]. In our study, we noted that the values of the hand grip were lower at T_2 compared to those observed at T_1, especially for the left hand grip (LHG) values ($P < 0.05$) (Fig. **1**). Moreover, a significant decrease is noted in the 30 s jumping tests ($P < 0.05$), which evaluated the power of the leg extensor muscles, considered to reflect anaerobic characteristics [5]. An explanation for this decrease in performance is the possibility of altered acid-base balance after subjects had lost weight. Greenhaff et al. [17] suggest that, even with adequate energy intake, a low carbohydrate diet may diminish the buffering capacity of the blood. So, acidosis from the combination of weight loss and a low carbohydrate intake would decrease the muscle hydrogen ion efflux, which is known to accelerate fatigue during intense muscular contractions. In the present study, energy intake was 30% lower (Table **3**) with a contribution of carbohydrates inferior to French recommendations [19]. It may be the reason for the reduction of the static strength. Elevated plasma fatty acids observed at T_2 (Table **2**) and the subsequent inhibition of glycolysis [36] are also a possible explanation of the decreased performance after a 7d food restriction. In fact, a decreased rate of glycolysis due to elevated free fatty acids would limit the anaerobic metabolism required to sustain the high intensity of arm cranking. Moreover, van Dale et al. [47] found that a weight-reducing diet combined with exercise may impair vitamin B6 status. In our study, we found a decrease of this vitamin after T_2 ($P < 0.05$) (Table **3**). This was also the case for the magnesium values. Vitamin B6, a cofactor for glycogen phosphorylase and magnesium, an activation for kinases, are needed for glycogenolysis. An impaired status might decrease anaerobic capacity [14].

No changes in the 7s-jumping test were observed after the decrease of bodyweight (Fig. **1**). One factor responsible for the impaired capability in force production after weight reduction could concern the contractile part of the muscle cells or the nervous system. In the case of vertical jumping, possible changes in the visco-elastic properties of the muscular system may also be of importance [48]. Moreover, in the 7s-jumping test, the energy liberated from the phosphagen stores is of high importance. Houston et al. [24] found no changes in muscles' ATP and CP concentrations after a 4-day period of weight loss achieved by reduction in the food and liquid intake (as it is the case in our study, Table **3**). The lack of changes in the 7-s jumping test in our study corroborated these previous results.

Concerning the lipid profile, we first noted that our values were in agreement with the reference norms. Our results, secondly, also showed that 7-d food restriction and a decrease of body weight produced no change in C, LDL-C and HDL-C concentrations nor in apolipoprotein A1 and B (Table **2**). These results were not in agreement with previous studies [27,45] which noted significantly reductions in C and LDL-C where body weight decreased during exercise training and food restriction. Moreover, Thompson et al. [45] reported that a low carbohydrate diet (17% proteins, 43% carbohydrates and 40% lipids) induced an increase of HDL-C and Apo-A1. These contradictory results can be due to the timing of lipid measurements in the interpretation of the plasma lipid response to weight loss. Other important factors like the dietary composition of the weight loss strategy, or the type of exercise during weight loss, must be taken into account and can explain the controversial data in the literature [32]. LDL-C concentrations at T_1 and T_2 were lower than the reference values, corroborating other studies, which observed the involvement of physical activity on reduction in the LDL-C preventing arthrogenic risks [20]. Most of the studies interested in relationship between exercise and plasma lipoproteins showed significantly higher plasma HDL-C values in athletes compared to those noted in inactive controls, particularly in endurance-trained men [1]. These high HDL-C values would induce risk factors for coronary heart disease [16]. However, the influence of exercise on HDL-C depends in the characteristics of the sport practised. Several studies have noted that sportsmen participating in speed or power events, like weight lifting, have plasma HDL-C values similar those of sedentary controls [12]. Our results were in agreement with these studies. It has also been shown that weight reduction may lead to alterations in lipid and lipoprotein file with a reduction of TG [27]. However, the results are under debate, predominantly because of the different regimes used in studies. Moreover, the different lipid parameters are influenced by the type of sport and anaerobic activities have received little attention. In our study, baseline TG values (T_1) were low (0.63 ± 0.07 mmol $\times$ l^{-1}). These values were in agreement with other previous studies, which also reported lower basal plasma TG concentrations in sportsmen, whatever the sport practised, compared with the general population [20]. The FFA increase observed in our study after food restriction ($P < 0.05$: Table **2**) may be the consequence of the increase of the lipolysis of TG in adipose tissue and circulating TG [26], and of the hormonal adaptations induced by training, i. e. sensitivity to catecholamines, which improves lipids utilisation [6,46]. The lack of changes of glycerol levels may be attributed to the use of the glycerol by the hepatic neoglucogenesis inducing from the low carbohydrates intake.

The findings of the mood states showed that subjects were characterised by the "iceberg" profile at T1 previously identified in sport research as a successful mood profile [21]. However, weight loss eliminated this profile by lowering the positive mood state of vigor and increasing the negative mood states of tension, anger, fatigue and confusion. Our data are in agreement with those of Newton et al. [31] and Steen et al. [38] in competitive bodybuilders or in wrestlers. These modifications noted in the POMS tend to mirror the changes that occur when athletes overtrain [30].

In conclusion, the data indicate that a 7-day food restriction adversely affects the physiology and psychology of judo athletes and impairs physical performance, possibly due to inadequate intake of carbohydrates and micronutrients.

References

1 Adner MM, Castelli WP. Elevated high density lipoprotein levels in marathon runners. JAMA 1980; 243: 534 – 536

2 Aellen R, Hollmann W, Boutellier U. Effects of aerobic and anaerobic training on plasma lipoproteins. Int J Sports Med 1993; 14: 396 – 400

3 Bijlani RL, Sharma KN. Effect of dehydration and a few regimens of rehydration on human performance. Int J Pharmacol 1980; 24: 255 – 260

4 Bosco C. Sei un grande athleta: vediamo cosa dice l'ergojump. Pallavolo 1980; 5: 34 – 36

5 Bosco C. A simple method for measurement of mechanical power in jumping. Eur J Appl Physiol 1983; 50: 273 – 282

6 Brouns F, van der Vusse GJ. Utilization of lipids during exercise in human subjects: metabolic and dietary constraints. Br J Nutr 1998; 79: 117 – 128

7 Brown RC, Cox CM. Effects of high fat diets on plasma lipids and lipoproteins in endurance athletes. Med Sci Sports Exerc 1998; 30: 1677 – 1683

8 Brownell KD, Steen SN, Wilmore JH. Weight regulation practices in athletes: analysis of metabolic and health effects. Med Sci Sports Exerc 1987; 19: 546 – 556

9 Cardoso Saldana GC, Hernandez de Leon S, Zamora Gonzales J, Posadas R. Lipid and lipoprotein levels in athletes in different sports disciplines. Arch Inst Cardiol Mex 1995; 65: 229 – 235

10 Durnin JVGA, Rahaman MM. The assessment of the amount of fat in the human body from measurement of skinfold thickness. Br J Nutr 1967; 21: 681 – 689

11 Dupin H, Abraham J, Giachetti I. Apports nutritionnels conseillés pour la population française. Centre National de la Recherche Scientifique. Paris: CNERMA Lavoisier. Tec. Doc. Paris, 1992

12 Farrel PA, Maksud MG, Pollock ML. A comparison of plasma cholesterol, triglycerides, and high-density lipoprotein cholesterol in speed skaters, weightlifters and non-athletes. Eur J Appl Physiol 1982; 48: 77 – 82

13 Fogelholm GM, Koskinen R, Laakso J, Rankinen T, Ruokonen I. Gradual and rapid weight loss: effects on nutrition and performance in male athletes. Med Sci Sports Exerc 1993; 25: 371 – 377

14 Fogelholm GM. Effects of bodyweight reduction on sports performance. Sports Med 1994; 18: 249 – 267

15 Giada F, Zuliani G, Baldo-Enzi G, Palmieri E, Volpato S, Vitale E, Magnanini P, Colozzi A, Vecchiet L, Fellin R. Lipoprotein profile, diet and body composition in athletes practising mixed and anaerobic activities. J Sports Phys Fitness 1996; 36: 211 – 216

16 Goldberg L, Elliot DL, Schultz RW, Kloster FE. Changes in lipid and lipoprotein levels after weight training. JAMA 1984; 252: 504 – 506

17 Greenhaff PL, Gleeson M, Maughan RJ. The effects of dietary manipulation on blood-acid-base status and the performance of high intensity work. Eur J Appl Physiol 1987; 56: 331 – 337

18 Guastella PJ, Wigand K, Pizza F. The effects of rapid weight loss on anaerobic power in high school wrestlers. Med Sci Sports Exerc 1988; 20: S2

19 Guezennec CY, Kleping Y, Cure M, Dulac J, Couzy F, Marechi JP. Apports nutritionnels recommandés en minéraux et oligo-minéraux dans l'alimentation des sportifs et des personnes à activités physiques élevées. Cahier de Nutrition et de diététique 1989; 1: 67 – 78

20 Haskell WL. The influence of exercise on the concentrations of triglyceride and cholesterol in human plasma. Exerc Sport Sci Rev 1984; 12: 205 – 244

21 Hassmen P, Koivula N, Torsten H. Precompetitive mood states and performance of elite male golfers: do trait characteristics make a difference? Percept Motor Skills 1998; 86: 1443 – 1457

22 Horswill CA, Hickner RC, Scott JR, Costill DL, Gould D. Weight loss, dietary carbohydrate modifications, and high intensity, physical performance. Med Sci Sports Exerc 1990; 22: 470 – 476

23 Horswill CA, Park SH, Roemmich JN. Changes in the protein nutritional status of adolescent wrestlers. Med Sci Sports Exerc 1990; 22: 599 – 604

[24] Houston ME, Marrin DA, Green HJ, Thomson JA. The effect of rapid weight loss on physiological functions in wrestlers. Physician Sports Med 1981; 9: 73 – 79
[25] Ivy JL. Muscle glycogen synthesis before and after an exercise. Sports Med 1991; 11: 6 – 19
[26] Jeukendrup AE, Saris WM, Wagenmakers AJM. Fat metabolism during exercise: a review. Part III: Effects of nutritional interventions. Int J Sports Med 1998; 19: 371 – 379
[27] Kraemer WJ, Volek JS, Clark KL, Gordon SE, Puhl SM, Koziris LP, McBride JM, Triplett-McBride NT, Putukian M, Newton RU, Hakkinen K, Bush JA, Sebastianelli WJ. Influence of exercise training on physiological and performances changes with weight loss in men. Med Sci Sports Exerc 1999; 31: 1320 – 1329
[28] Maso F, Jouanel P, Lac G, Robert A. Lipoarticles and other serum lipids in sportsmen: comparison with a control group. Int J Sports Med 2000; in press
[29] Mc Nair D, Lorr M, Droppleman LF. Profile of Mood States Manual. San Diego, CA: Educational and Industrial Testing Service, 1971
[30] Morgan WP, Costill DL, Flynn MG, Raglin JS, O'Connor PJ. Mood disturbance following increased training in swimmers. Med Sci Sports Exerc 1988; 20: 408 – 414
[31] Newton E, Hunter G, Bammon M, Roney R. Changes in psychological states-reported diet during various phases of training in competitive bodybuilders. J Strength Cond Res 1993; 7: 153 – 158
[32] Noakes M, Clifton PM. Weight loss and plasma lipids. Curr Opin Lipidol 2000; 11: 65 – 70
[33] O'Hanesian MA, Rosner B, Bishop LM, Sacks FM. Effects of inherent responsiveness to diet and day-to-day diet variation on plasma lipoprotein concentrations. Am J Nutr 1996; 64: 53 – 59
[34] Pilardeau P. Biochimie et nutrition des activités physiques et sportives. Paris: Editions Masson, 1995: 67
[35] Rankin JW, Ocel JO, Craft L. Effect of weight loss and refeeding diet composition on anaerobic performance in wrestlers. Med Sci Sports Exerc 1996; 28: 1292 – 1299
[36] Ruderman NB, Toews CJ, Shafur E. Role of free fat acids in glucose homeostasis. Arch Intern Med 1969; 123: 299 – 313
[37] Sävendahl L, Underwood LE. Fasting increases serum total cholesterol, LDL cholesterol and apolipoprotein B in healthy, nonobese humans. J Nutr 1999; 129: 2005 – 2008
[38] Steen SN, Brownell KD. Patterns of weight loss and regain in wrestlers. Has the tradition changed? Med Sci Sports Exerc 1990; 22: 762 – 768
[39] Stefanick ML, Mackey S, Sheehan M, Ellsworth N, Haskell WL, Wood PD. Effects of diet and exercise in men and postmenopausal women with low levels of HDL cholesterol and high levels of LDL cholesterol. New Engl J Med 1998; 1: 12 – 19
[40] Su-vi-max. In: Candia (ed). Portions alimentaires. Manuel photos pour l'estimation des quantités. Polytechnica, 1994
[41] Thomas SG, Cox MH, Legal Y, Verde TJ, Smith HK. Physiological profiles of the canadian national judo team. Can J Spt Sc 1989; 3: 142 – 147
[42] Thompson PD, Cullinane EM, Eshleman R, Sady SP, Herbert PN. The effects of caloric restriction or exercise cessation on the serum lipid and lipoprotein concentrations of endurance athletes. Metabolism 1984; 33: 943 – 950
[43] Thompson PD, Cullinane EM, Sady SP, Flynn MM, Chenevert CB, Herbert PN. High density lipoprotein metabolism in endurance athletes and sedentary men. Circulation 1991; 84: 140 – 152
[44] Too D, Wakayama L, Locati L, Landwer GE. Effect of precompetition bodybuilding diet and training regimen on body composition and blood chemistry. J Sports Med Phys Fitness 1998; 38: 245 – 252
[45] Tran ZV, Weltman A. Differential effects of exercise on serum lipid and lipoprotein levels seen with changes in body weight: a meta-analysis. JAMA 1985; 254: 919 – 924
[46] Turcotte LP. Role of fats in exercise. Clin Sports Med 1999; 3: 485 – 498
[47] Van Dale D, Schrijver J, Saris WHM. Changes in vitamin status in plasma during dieting and exercise. Int J Vit Nutr Res 1990; 60: 67 – 74
[48] Viitasalo JT, Kyröläinen H, Bosco C, Alen M. Effects of rapid weight reduction on force production and vertical jumping height. Int J Sports Med 1987; 8: 281 – 285
[49] Webster S, Rutt R, Weltman A. Psychological effects of a weight loss regimen practiced by college wrestlers. Med Sci Sports Exerc 1990; 22: 229 – 234
[50] Wood PD. Physical activity, diet and health: independent and interactive effects. Med Sci Sports Exerc 1994; 26: 838 – 843

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