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Influence of weight reduction on physical performance capacity in judokas

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Summary

Introduction. Physical performance capacity in judokas was investigated before and after weight reduction.

Material and methods. Twenty-two judokas volunteered to take part in the experiment and were tested before and after weight reduction. Body weight and body fat percentage was measured before and after weight reduction. Food intake before and during the weight reduction period was recorded. Reaction time was measured by means of a jump test, using the Optojump system (Microgate – Italy). Isometric arm strength was measured by tensiometry using a 40 seconds procedure. Anaerobic endurance was tested using a repeated jumping procedure.

Results. After the experimental procedures subjects were divided in a high weight reduction group (≥3% BW, n=11) and a light weight reduction group (<3% BW, n=11). In the high weight reduction group (HWRG) body weight changed from 72.0±12.3 kg to 69.0±11.8 kg, ($p<0.001$). In the light weight reduction group (LWRG) body weight changed from 66.6±8.6 to 65.7±8.4 kg, ($p=0.001$). Both groups showed very low carbohydrate intakes during the weight reduction period. Reaction time improved in one out of the three reaction tests for the HWRG ($p<0.05$). In the HWRG total isometric strength and isometric strength as measured during the 2nd maximal effort of the 40 s procedure, decreased significantly ($p<0.05$).

Conclusions. Only in the HWRG isometric strength was influenced negatively by the weight reduction procedure. Anaerobic performance was not influenced by the weight reduction procedure.

Introduction

Purposive weight reduction before judo competition is a widely-used and well-integrated procedure. Many athletes choose to lose weight to compete in a particular weight category below their normal body weight. The main goal of the athletes who "make weight" is to gain advantage of strength and power over opponents who do not reduce their body mass for the same weight class [1].

The high health, injury risk associated with rapid weight regimes [2] and the prevalence of weight loss among judo competitors [3,4] resulted in the request for a weight management control program in judo as proposed by Artioli et al. [2,4].

Various aspects of physical performance capacity are important for a judoka. As such are: anaerobic performance capacity, maximal isometric strength, maximal dynamic strength, explosive strength, reaction speed, specific coordination and active litheness [5,6].

Negative effects of weight reduction on performance capacity in wrestlers and judokas are reported [1,7-9]. Moreover, weight reduction procedures can bring interference in an optimal preparation [10]. Indeed, the heavy training load, the low caloric intake and the dehydration procedure – sometimes combined – during the weight reduction period, can result in overtraining, low muscle glycogen levels, loss of muscle mass, loss of strength, and dehydration [11]. The study of Filaire et al. carried out on judo athletes after a food restriction period of 7 days, indicates a significant decrease in left but not in right arm hand grip strength and a significant decrease in jumping performance during a 30 seconds jump test but not during a 7 seconds jump test [10].

Degoutte et al. reported a significant reduction in left hand grip strength when comparing pre- and post weight reduction measured before a competition simulation for the food restriction group (7 days food restriction period) only [9]. The study of Umeda et al. reported a decreased performance on a non judo specific anaerobic power test for judokas in the high weight reduction group (4.1±2.8% of body weight) but not for the low weight reduction group (1.3±1.0% of body weight) [12]. Using a combination of gradual and rapid weight loss program, Koral & Dosseville found a decreased number of judo movements over 30 s for the weight loss group but not for the control group. Squat jump and countermovement jump performance, and number of judo movements over 5 s were not influenced by the weight loss procedure [13].

To our knowledge reports on changes in reaction time in judokas after weight reduction are not available. Singer & Weiss found no changes in reaction time while Kraemer et al. found an improvement in reaction time after 6% weight loss in wrestlers [14,15].

On the other hand, Kim and Widerman & Hagen succeeded in their attempt to combine weight loss with the preservation of anaerobic exercise performance [16,17]. As demonstrated by Kraemer et al. and by Artioli et al. the time elapsed between weigh-in and performance, allowing re-feeding and re-hydration strategies, may be sufficient to counter-act the possible negative effects of the weight reduction on wrestler and judo related performance respectively [4,15].

The American College of Sports Medicine questions the positive consequences of weight reduction [18]. Indeed, results of weight reduction practices on the physical performance capacity in judokas remains equivocal. The purpose of this study was to investigate the effect of weight reduction on specific physical performance capacities. More in particularly we evaluated general anaerobic performance capacity, maximal isometric strength and reaction time of judokas pre and post weight reduction.

Material and methods

Participants

Twenty-two judokas (mean age 22.73±5.51 years) volunteered in the experiment after giving informed consent. The group consisted of 15 male (24.30±5.51 years) and 7 female athletes (19.29±2.19 years). All of them were competitive judokas, ranging from regional to international level. Competition weight of the male judokas was -60 (n=3); -66 (n=3); -73 (n=4), -81 (n=3); -90 (n=2); and -48 (n=1); - 53 (n=2); -57 (n=1); - 63 (n=1); - 70 (n=1) for the female judokas. All subjects were asked to perform a weight reduction up to competition weight, without time limits, using their own weight reduction procedure. All subjects were tested on two occasions, before (pre) and after (post) weight reduction. The subjects were retrospectively assigned to a high weight reduction group (HWRG, ≥3% weight reduction) and a low weight reduction group (LWRG, <3% weight reduction).

Body weight and body fat percentage

Body weight was measured with a Tanita BWB-600 balance. Body fat was estimated by three different methods: (1) skin fold measures (triceps, subscapula, abdomen) and Lohman Equation [19]; (2) bio-electrical impedance measures with the Omron BF300 instrument (hand-hand) and (3) with the Tanita TBF-410 (foot-foot) apparatus used in the athlete mode.

Energy intake

Daily nutrient intake was recorded 7 days prior to the test sessions using a 7 days food dairy. Subjects were instructed how to complete the food diaries and information concerning quantities and portion size was given. Total energy intake and macronutrient distribution (energy % and absolute values in g/day) were calculated.

Reaction test

Reaction time was measured using the Optojump apparatus and software (Microgate, Italy). The reaction test measured the time between the appearance of a visual stimulus on the monitor of the computer screen and a jump. This test was repeated three times with rest intervals of at least 15 seconds. The three reaction times were analyzed separately.

Isometric strength test

Isometric arm strength was measured by tensiometry. A curl bar connected with the tensiometer (containing a strain gauge) was pulled towards the trunk by bending the forearms up to an angle of 90° relative to the upper arms. The main muscles involved were biceps and the forearm muscles. After a determination of the maximal isometric strength (isomax0), the following time and intensity procedure was used: (1) fixing at 60% of the maximal isometric strength during 10 seconds, (2) maximal effort during 3 s (isomax1), (3) 60% during 7 s, (4) maximal effort during 3 s (isomax2), (5) 60% during 7 s, (6) finishing with a maximal effort during 10 s (isomax3). This procedure was selected as an imitation of the immobilisation techniques used in the ne-waza (ground) fight. The mean value of the different maximal isometric intervals was taken as an indication for isometric strength performance. Total isometric strength (isomaxT) produced over the different efforts was calculated (isomaxT =∑isomax1+ isomax2 + isomax3).

Anaerobic endurance test

An anaerobic endurance test was required to estimate the anaerobic performance capacity of judokas [6,20,21]. An interval test consisting out of 5 series of 20 maximal jump squats interspersed with 1 minute rest intervals was used. The intermittent character of the all out jump test was chosen as a simulation of the exercise pattern of a judo match (5 minutes of real fight interspersed with non activity), [20]. The used method estimates the anaerobic endurance capacity of the judoka with a major contribution of the leg muscles. In their recently presented distribution of energy expenditure during judo throwing, Blais et al. demonstrated the predominance of the lower limbs compared to a lower contribution for the trunk and the upper limbs [22].

The Optojump apparatus and software to register the contact and flight times was used. These parameters allowed to calculate the height of the different jumps. The mean height of the different jump series was calculated.

Heart rate was measured using a Polar S-810 monitor. Heart rate was monitored until two minutes after the last series of 20 jumps.

Statistics

After testing for normality (Kolmogorov Goodness of Fit test) pre- and post weight reduction values for the HWRG and the LWRG respectively were compared using a paired t-test. HWRG and LWRG were compared using an unpaired t-test. An ANOVA test was used to analyse the mean values of jump height and the mean heart rate values during the jump test pre- and post weight reduction. The significance level was set at 5%.

Results

Body weight and body fat percentage

In the HWRG body weight decreased from 72.0±12.3 kg to 69.0±11.8 kg when comparing pre and post weight reduction values, (p<0.001). Body weight reduction in the LWRG was modest, from 66.6±8.6 to 65.7±8.4 kg, but still significant (p=0.001) (Table 1). The subjects from the HWRG performed a mean weight reduction of 4.19±1.24% of their total body mass under normal conditions whilst the LWRG reduced their body mass with 1.33±0.95%. The mean time used to obtain competition weight was 5±3 days ranging from 1 day up to 14 days.

Body fat % as estimated by the Lohman method and with the Tanita instrument decreased significantly in the HWRG but not in the LWRG. Using these values for the calculation of the fat mass lost during the weight loss procedure results in the following values: 0.02 kg (Lohman) and 0.69 kg (Tanita) for the LWRG and 1.83 kg (Lohman) and 1.72 kg (Tanita) for the HWRG. Values of the Omron instrument indicated no significant changes when comparing pre with post weight reduction values for the respective groups.

Energy intake

Daily energy intake differed significantly (p<0.01) when comparing normal intake with energy intake during the weight reduction period for both the LWRG and the HWRG (Table 2). A decrease of 1857±1444 and 1654±1632 was calculated for LWRG and the HWRG respectively. Compared to reference values of moderately physically active persons this means a caloric deficit of 1871 kcal/day for the women (ref. value 2200 kcal/day) from the LWRG and of 1773 kcal/day for the men (ref. value 3050 kcal/day) of the LWRG. Similarly, for the HWRG this means a caloric deficit of respectively 1725 kcal/day for the women and 1675 kcal/day for the men.

During the weight reduction period macro-nutrient intake (energy %) changed towards an increased contribution of carbohydrates. This was significant for the LWRG but not for the HWRG. However, this means a carbohydrate intake of only 168 g/day for the LWRG and 117 g/day for the HWRG. Using a reference value of carbohydrate intake of 8 g/kg body weight/day brings the required intake to respectively 525 g/day for the LWRG and 552 g/day for the HWRG. The contribution of fat intake (energy %) decreased significantly in the LWRG and the HWRG. The contribution of protein (energy %) was comparable under normal eating conditions versus weight reduction conditions. Again this means an intake of only 49 g protein/day for the LWRG and 41 g protein/day for the HWRG while minimal intakes (reference value 1.2 g/kg body weight/day) are respectively 79 g/day and 83 g/day.

Reaction test

Reaction time was unaffected in the reaction tests for the LWRG while a significant shorter reaction time was found for the third reaction test in the HWRG when comparing post weight reduction test with pre weight reduction test (Table 3).

Tab. 1. Anthropometric parameters measured before and after the weight reduction period. LWRG: low weight reduction group, HWRG: high weight reduction group. [a]=p<.05 when comparing pre- with post weight reduction values. [b]=p<.05 when comparing LWRG with HWRG

	LWRG		HWRG	
	Pre	Post	Pre	Post
Body weight (kg)	66.6±8.6	65.7±8.4[a]	72.0±12.3	69.0±11.7[a]
Body fat % (Lohman)	9.8±3.9	9.9±2.4	15.0±5.0	13.0±4.8[a]
Body fat % (Omron)	9.5±5.2	8.8±5.4	13.7±6.4	13.6±6.2
Body fat % (Tanita)	10.7±4.7	9.8±2.4	15.9±4.4[b]	14.1±4.7[a]

Tab. 2. Energy intake and contribution of the different macro-nutrients estimated before and during the weight reduction period. LWRG: low weight reduction group, HWRG: high weight reduction group. [a]=p<.05 when comparing pre- with during weight reduction values

	LWRG		HWRG	
	Pre	During	Pre	During
Daily energy intake (kcal)	3028±1509	1172±612[a]	2529±1433	875±931[a]
Energy % carbohydrates	52.4±7.0	60.1±9.6[a]	45.2±6.8	56.5±17.4
Energy % protein	17.4±6.8	16.8±5.6	22.4±4.8	20.5±8.7
Energy % fat	29.1±4.8	22.5±9.2[a]	29.4±6.2	20.3±9.4[a]

Tab. 3. Reaction time before and after the weight reduction period. LWRG: low weight reduction group, HWRG: high weight reduction group. [a]=p<.05 when comparing pre- with post weight reduction values

	LWRG		HWRG	
	Pre	Post	Pre	Post
Reaction time 1 (ms)	478±172	474±101	514±113	544±131
Reaction time 2 (ms)	458±65	419±64	506±76	504±81
Reaction time 3 (ms)	435±63	427±69	518±106	477±98[a]

Tab. 4. Maximal isometric contraction before (isomax0) and at specific intervals (isomax1, isomax2, isomax3) during the 40s test procedure before and after the weight reduction period. LWRG: low weight reduction group, HWRG: high weight reduction group. [a]=p<.05 when comparing pre- with post weight reduction values, [c]=p<.1 when comparing pre- with post weight reduction values

	LWRG		HWRG	
	Pre	Post	Pre	Post
Isomax0 (N)	49±10	52±9	52±21	45±16[c]
Isomax1 (N)	47±9	48±8	44±16	38±13[c]
Isomax2 (N)	46±9	46±8	42±16	36±11[a]
Isomax3 (N)	44±8	45±9	39±15	33±9[c]
IsomaxT (N)	135±25	137±23	126±47	108±34[a]

Tab. 5. Mean jumping height of 20 jumps during the different jump series (1 to 5) before and after the weight reduction period. LWRG: low weight reduction group, HWRG: high weight reduction group

	LWRG		HWRG	
	Pre	Post	Pre	Post
Mean jumping height 1 (cm)	237±47	260±68	221±53	220±45
Mean jumping height 2 (cm)	239±57	252±64	208±44	208±35
Mean jumping height 3 (cm)	240±58	244±61	200±42	206±35
Mean jumping height 4 (cm)	238±72	241±58	193±37	195±32
Mean jumping height 5 (cm)	233±62	235±55	186±35	186±45

Isometric strength test

Isometric strength was unaffected in the LWRG (Table 4). In the HWRG isometric strength measurements showed a tendency ($p<0.1$) towards lower values after the weight reduction period (isomax0, isomax1 and isomax3) while isomax2 was significantly lower after the weight reduction period ($p<0.05$). IsomaxT differed significantly when comparing pre- and post weight reduction values for the HWRG only ($p<0.05$).

Anaerobic endurance test

Mean jumping height calculated for the different series was unaffected by the weight reduction procedure for the LWRG and for the HWRG (Table 5). Equally no differences were found for ground contact times and heart rate measurements (data not shown).

Discussion

The post experiment attribution to a LWRG (<3% weight reduction) and a HWRG (≥3% weight reduction) resulted in 2 females (1x -48 kg and 1x –57 kg) and 9 males (3x–60 kg, 3x–66 kg, 2x–73 kg and 1x–90 kg) in the LWRG. The HWRG consisted of 5 females (2x–53 kg, 1x–63 kg and 1x–70 kg) and 6 males (2x–73 kg, 3x–81 kg and 1x–90 kg). The subjects of the LWRG belonged to the light to middle weight categories (except 1 male – 90 kg) while those of the HWRG compete in the middle to heavy weight categories. Although the anthropometric values (body weight, % of body fat) tended to be higher for the HWRG, significance was reached for the estimation of body fat by the Tanita instrument only. Indeed, with more female subjects and more judoka's from heavier weight categories one may expect higher weight values and a body fat percentage for the subjects of the HWRG.

The weight reduction procedure resulted in a reduction in body weight of 1.4% for the LWRG and 4.2% for the HWRG. These values are completely comparable with the results of Umeda et al. who reported a reduction of respectively 1.4% for the LWRG and 4.1% for the HWRG [12]. Other experiments reported values of the same magnitude for their judokas under weight reduction: respectively 4.9% [10], 5.0% [9] and 3.3% for the male subjects and 4.6% for the female subjects [13]. For the subjects in the HWRG these percentages were respectively 4.1% for the females (n=5) and 4.3% for the males (n=6).

Using the Lohman equation and the Tanita instrument we found a significant decrease of body fat percentage for the subjects of the HWRG, respectively 2% and 1.8%. This is in agreement with the HWRG of Umeda et al. and with the results of Degoutte et al. [9,14], while the reduction in body fat percentage did not reach significance in the studies of Filaire et al. and Silva et al. [10,23]. The latter study used skin fold measurements and a 4 compartment model to estimate the percentage of body fat in highly trained judo athletes [23].

Several studies provide coaching during the weight reduction procedure [24-26]. Only few studies imposed a specific weight reduction procedure and offered professional guidance [1,13,17]. Within the limitations of our study it was not possible to fully control the weight reduction procedure in all 22 individuals. A similar strategy was used by others [11,15,27]. Also in the more recently published judo research, no specific weight reduction strategies were imposed [23]. In the studies of Filaire et al. and Degoutte et al. a weight reduction period of 1 week was used while the study of Umeda et al. provided a period of 20 days [9,10,12]. In the study of Koral & Dosseville, a combined gradual (caloric restriction 4 weeks before reaching competition weight) and rapid weight loss procedure (caloric restriction and dehydration 1 week before reaching competition weight) was used [13].

Dietary intake decreased significantly for the LWRH and the HWRG resulting in a caloric deficit for both groups. In comparison with the reports of Filaire et al. and Umeda et al. the total caloric intake for the HWRG during the last week of the weight reduction period is very low: respectively 2102± 179 kcal/day and 1761±703 kcal/day versus 875±931 kcal/day in our experiment [10,12].

For the HWRG a fat loss of 1.7 kg (Lohman) or 1.8 kg (Tanita) was calculated, which seems acceptable with an estimated caloric deficit around 1700 kcal/day during the weight reduction period.

Analysis of the different macronutrients revealed a significant decrease for the contribution of fat in the weight reduction diet (energy %) with an increase for carbohydrates and protein. However when analyzed as absolute intakes (g/day) very low intakes for carbohydrates and protein are noticed for the HWRG but equally for the LWRG. The estimated intake for the HWRG (117 g/day) during the weight reduction period is lower compared to the values obtained by Filaire et al. and by Umeda et al. but comparable with the values reported in the wrestlers of Tarnopolsky et al. [10-12]. The detrimental effect of weight reduction procedures on the muscle glycogen concentration has been demonstrated by Tarnopolsky and coworkers [12]. The intermittent activity pattern of judo, with several matches on the same day requires an optimalisation of the muscle glycogen levels which is not possible during periods of low carbohydrate intake, dehydration and heavy training [8,20].

Reaction time was not impaired by the weight reduction procedure. For the HWRG we even noticed an improvement in reaction time for the third reaction test. This corroborates the findings of Kraemer et al. who found an improvement in reaction time for a stand-up drill in wrestlers after a weight reduction procedure [15]. However, such an improvement of reaction time remains difficult to explain and further study on that topic is needed.

We noticed that maximal isometric strength values tented to be lower in the HWRG post weight reduction. Differences became significant during the second maximal isometric contraction and for the total isometric strength as measured over the procedure. No differences were detected for the LWRG. We used the isometric strength procedure as an imitation of the frequently used immobilisation techniques. During an immobilisation technique biceps and underarm muscles work at different intensities as a function of the opposition of the opponent. This procedure had also the advantage that a larger, judo specific muscle mass is involved compared to the measurement of handgrip strength only. A reduction in handgrip strength was reported for the left hand but not for the right hand in the experiments of Filaire et al. [10]. Degoutte et al. reported equally a decrease in maximal muscular strength as measured with a hand dynamometer when comparing pre and post weight reduction values [9]. Kraemer et al. found no change in handgrip strength [15]. Also, a more wrestler-specific test (including hand and arm grip strength) was not influenced after a weight reduction of 6% [19]. However, the latter authors allowed a 12 hours recuperation (foods and drinks) between the weigh-in and the test period.

The anaerobic jumps test was not influenced by the weight reduction. This is in agreement with the results of Kim and Widerman & Hagen [16,17]. Filaire et al. found no effect of weight reduction on a single simple jump test, a single countermovement jump test and a 7 s jump test when comparing pre- with post weight reduction values [10]. However, the performance on a 30 s jump test decreased significantly over the same period. In the recently published study of Koral & Dosseville single jump performance in a squat jump and a countermovement jump (as an indicator for visco-elastic properties of the muscular system) was not influenced by the weight reduction period [13]. Equally, these authors found no effect of weight reduction on a 5 s judo movement test while performance was significantly reduced on the 30 s judo movement test. The latter is again in contradiction with our results on the anaerobic jump test procedure. In the experiment of Umeda et al. peak anaerobic power decreased for the high weight reduction group but not for the low weight reduction group as measured on a cycle ergo-meter while mean power output was not affected during their intermittent anaerobic test procedure (eight series of 10 s full power cycling interspersed with 20 s rest) [12].

Again, the results of the different jump and anaerobic tests as found in the literature are difficult to compare. Our test and the tests reported in the literature lack specificity for judo (except the 5 s and 30 s judo movement test [13]. We optioned the Optojump test because of the availability and the possibility to use an intermittent exercise pattern with recuperation periods in between bursts of maximal output. Moreover, the recently published report of Blais et al. indicated that the expenditure of energy in the lower limbs was significantly higher during the throwing technique Morote Seoï nage compared to the upper limbs and the trunk [22].

Conclusions

The literature on physical performance capacity after a weight reduction period remains equivocal. In the majority of the studies, some aspects of physical performance capacity are negatively influenced while other capacities remain unaffected. A shortcoming of the present and most of the reported studies is the limitation to a single test moment while performance during a judo tournament is of repetitive nature. Indeed, the approach used by Kraemer et al. clearly demonstrated a progressive decrease in performance for the wrestlers after 6% weight reduction using a 2 days simulated wrestling tournament [15]. However, judo tournaments are single day events with several fights on the same day. The use of the Special Judo Fitness Test may increase the judo specificity while repetition of the test after different recuperation periods (a long recuperation period simulating the time between weigh-in and first combat and shorter recuperation periods to simulate the recuperation between combats) may be a good simulation for a competition day [4,6,21].

We analyzed different aspects of physical performance capacity before and after weight reduction in a low weight reduction group (<3%) and a high weight reduction group (≥3%). In both groups, body weight and percentage body fat decreased significantly after he weight reduction. During the weight reduction period, nutritional intake was hypo caloric and too low in carbohydrates and protein for the low and the high weight reduction group. This may hamper recuperation and optimalisation of energy stores before the competition. Anaerobic endurance (repeated jumping procedure) was not influenced by weight reduction. Isometric strength decreased significantly after a weight reduction of 4.19±1.24% of body weight and remained unaffected after a weight reduction of 1.33±0.95% of body weight.

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