Physiological and psychological performance of taekwondo athletes is more affected by rapid than by gradual weight reduction

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Abstract

Background & Study Aim: The results of previous studies regarding the impact of different forms of weight reduction on performance capacity are not consistent. Therefore, the purpose of this study was the knowledge about the effects of RWR and GWR in Taekwondo athletes on physiological and psychological changes and performance with the sport specific investigation.

Materials & Methods: After baseline measurements, participants reduced weight by 5% within four days (RWR) followed by subsequent measurements. Additional measurements were performed one day post RWR followed by another two baseline measurements in the following weeks before the participants had to reduce 5% of their weight within four weeks (GWR). A final measurement was conducted one day post GWR. Anthropometry, vertical jumps, kick-frequencies and lactate production rate were assessed. Blood glucose, creatine kinase, creatinine, urea and electrolytes were analysed reflecting physiological changes after weight reduction. The psychological analyses comprised an adjective list of Perceived Physical State (PEPS).

Results: Body weight and water were significantly decreased after RWR and GWR ($p<0.01$) but body fat was only significantly decreased after GWR ($p<0.01$). Vertical jumps were significantly higher after RWR and kick-frequencies were higher after GWR ($p<0.01$). The impairments of blood indicators and scale values of PEPS were more predominant in RWR ($p<0.05$, $p<0.01$).

Conclusions: Overall, better results regarding physiological and psychological performances were achieved after GWR. Trainers and athletes should schedule GWR to achieve the desired weight prior to a competition so that a potential decline in performance can be avoided.

Key words: creatinine • creatine kinase • electrolytes • kick-frequency • urea • weight loss

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Rapid Weight Reduction (RWR) - reduces performance capacity in Taekwondo Athletes.

Gradual Weight Reduction (GWR) - prevents the reduction in performance capacity. GWR should be favoured over RWR in order to reach desired weight class to avoid potential decline in physiological and psychological performances.

Sport specific indicators - such as kick-frequency, are particularly affected and maintained with GWR.

Introduction

The combat sport Taekwondo (TKD) belongs to the official Olympic sports since 2000 Sydney Olympic Games. TKD is a high-speed, high-tension, full-contact sport and requires high technical, tactical, physiological and psychological skills and capabilities [1,2]. The athletes must qualify for competition by weigh-in at a competitive weight class. The weigh-in takes place one day prior to competition day [3]. Qualifying, semi-final, and final matches are carried out on one day so that athletes can have up to 5 fights in approximately 13h [3, 4]. In this regard, many athletes of combat sports prefer the rapid weight reduction (RWR) in order to fight at the upper limit of the next lighter weight class and to encounter smaller and weaker opponents [5,6].

The major problem of RWR is a negative effect on the athletic performance [7,8]. RWR is associated with decreased fluid levels in the body, which are induced by dehydration, sauna sessions and endurance training sessions while wearing thermal clothing to reduce weight [6,9]. Oppliger et al. [10] emphasize that the decrease in plasma volume and circulating blood amount during RWR can elicit an increase in heart frequency with simultaneous decline of stroke volume, and blood pressure. Furthermore, RWR can cause impairments of muscle strength, thermoregulatory processes, depleted muscle glycogen stores, and electrolyte equilibrium with a lack of sodium and potassium [11, 12]. Both, increased and decreased electrolyte concentrations damage the action potential for the muscle contraction leading to muscular fatigue [11] and a decrease in aerobic endurance capacity and performance [10, 13, 14]. The effect of RWR on anaerobic performance is still controversial. The main reasons for this controversy are due to missing sport-specific investigations, diverse periods, decreased percentages of the weight and different methods of RWR applied, e.g., uses of diuretic and laxative [5,7,10,13,15]. Moreover, fasting might cause psychological deficits (e.g. mood states, cognitive processing speed and risk). Especially after RWR eating disorder may occur [6, 16]. It was demonstrated that the mood state scales of anger, fatigue, and tension were increased while vigour was decreased in RWR [13,17].

Gradual weight reduction (GWR) with recommended weight reduction of 0.6-1 kg/week over four weeks has been shown to not affect vertical jumps and judo specific performances [7,18]. Also, indicators assessed using Profile of Mood State (POMS) were more positive in judo athletes [7].

Regarding the problems associated with fasting, it must also be considered that the period from the weigh-in to the competition day is rather short. Although fluid and macronutrient intake starts right after weigh-in to induce a rapid rehydration of the athlete, the recovery of the entire performance is, however, not possible within several hours. It takes 24-72h to re-establish fluid homeostasis and replenish muscle. Thus, this is not achieved by TKD athletes considering a recovery phase of at most 20h between weigh-in and competition [3,5,9,10].

The results of previous studies regarding the impact of RWR and GWR on performance are not consistent because the protocols of investigations are often not comparable or not coincident. Previous studies have rarely examined sport specific tests regarding GWR by TKD athletes. Therefore, the purpose of this study was the knowledge about the effects of RWR and GWR in TKD athletes on physiological and psychological changes and performance with the sport specific investigation.

Materials and Methods

Subjects

Ten well-trained male TKD athletes of different weight classes (21.1 ± 5.48 years, 1.74 ± 0.08 m, 71.6 ± 11.1 kg) participated in this study. They were familiar with TKD specific high training and endurance loads for at least 10 years and possessed individual experiences in body weight reduction. Subjects did not take any medication during the entire procedure. This study was approved by the institutional Ethics Committee of the German Sport University Cologne and in line with the Declaration of Helsinki [19]. All subjects signed an informed consent form.

Experimental design

The study was characterized by two phases of weight reduction including weight reduction by 5% during four days (RWR) and four weeks (GWR), respectively. Both interventions were separated by a recovery phase and measurements took place on a total of eight investigation days (see Figure 1). The nutritional and activity status for each subject was analysed and the individual demand for GWR was calculated by a nutritionist and exercise physiologist of the Institute of Biochemistry (German Sport University Cologne).

During RWR, weight loss was achieved by participants' individually used methods which included higher training intensity and training sessions with thermal clothing, fasting and dehydration. Weight

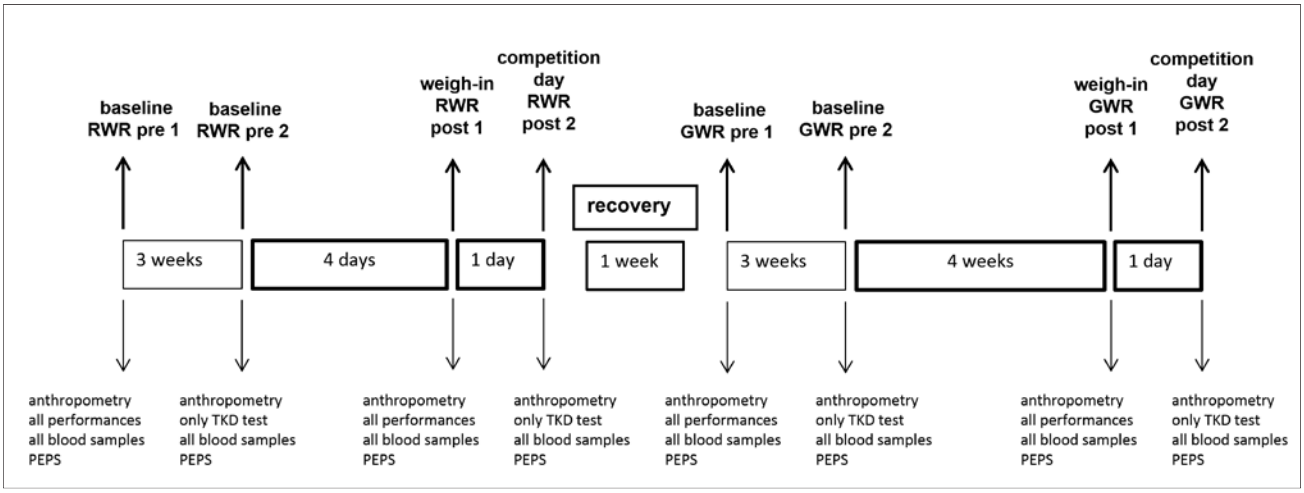

Figure 1. Experimental design with three week baseline, four day rapid weight reduction (RWR), four week gradual weight reduction (GWR), simulated competition day and associated parameters. *pre 1and 2 = baseline, post 1 = weigh-in and post 2 = simulated competition day

loss during GWR was achieved by combining exercise with minimal caloric intake (low-energy and high density foods) (Table 1). All athletes continued their sport specific training schedule (6-8h per week) with an additional running-training session (1h/week).

Blood samples were collected in the morning on each investigation day under fasting conditions. Anthropometric measurements as the actual weigh-in started in the afternoon. The psychological mood state analyses and other performance tests were conducted afterwards.

Table 1. Nutritional diet plan for four week gradual weight reduction

Contents	Light weight classes ≤ 8374 kJ·d^{-1} (n=4)	Heavy weight classes ≤ 9211 kJ·d^{-1} (n=6)
Protein (g·d^{-1})	100	130
Carbohydrate (g·d^{-1})	250-300	250-300
Fat (g·d^{-1})	50-60	70
Vegetables (g·d^{-1})	700	700
Fruit (g·d^{-1})	200	200
Water (L·d^{-1})	2	3

Anthropometric measurements

Weight was documented daily using identical scales for the analysis of the weight reduction process (BG-17 Beurer, Söflinger, Germany).

Body weight [kg], body water [kg], and body fat [%] were measured at all test days by using a single frequency bioimpedance analyser BIA (BC-418 MA Tanita, Hoofddorp, The Netherlands) in standing position, barefooted and with light indoor clothing and arms slightly abducted. Additionally, a Harpenden calliper was used to measure the 10 skinfold thicknesses [20].

Vertical jump measurements

Unspecific performance tests were carried out at the first baseline test (pre-test 1) and after each weight reduction protocol (post-test 1). The squat jumps (SJ) and countermovement jumps (CMJ) were performed on a force platform (DigiMax-mechaTronic, Hamm Quattro Jump-Kistler Instrumente AG, Winterhur, Switzerland). The shift of the body centre was assessed for the jumping height. Prior to the main measurement, all subjects performed three jumps as warm-up. Then, participants had three attempts for each jump. The position was controlled before every jump by the investigator. The best height was used for statistical analysis.

Taekwondo specific performance evaluation

The TKD specific anaerobic test consisted of lactate production rate (LPR) and kick-frequency. The latter was counted from the investigator and measured from the TKD electronic protector (TK-Streike, E-Protector System Version 4.2, Daedo International, Barcelona, Spain). Specific kicks (*Dollyeo-Chagi*) were directed towards the electronic protector during 5 s to warm-up (Figure 2A). After warm-up, capillary blood was taken from the earlobe to determine resting lactate level. As a first resting-test the maximum load was performed within 5 s followed by 3 min rest and a second resting blood lactate measurement afterwards. Then, 6

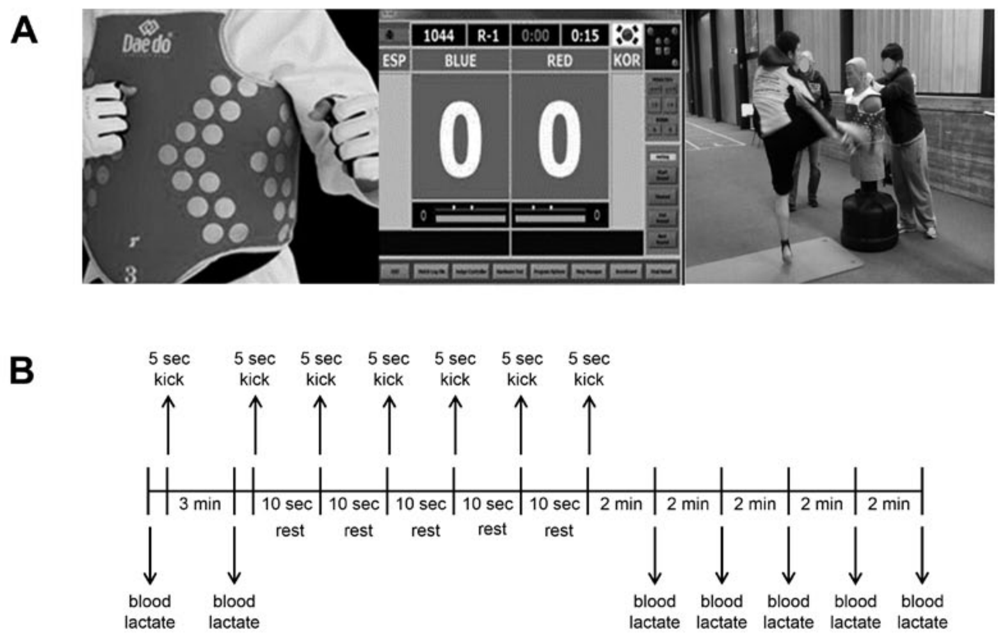

Figure 2 A E-protector, software (scoreboard), test of Taekwondo specific kick Dollyeo-Chagi

Figure 2 B the protocol for Taekwondo specific anaerobic diagnostic

series of maximum loads were performed with lactate samples taken 2, 4, 6, 8 and 10 min afterwards (Figure 2B). For the standardization of the anaerobic measurement, participants were seated during blood samplings so that a function of the lactate clearance could be neglected, since the maximum oxygen uptake into the muscle was low in this position. The blood lactate was analysed by an enzymatic-amperometric sensor chip system (Biosen S-line, EKF-diagnostic sales, GmbH, Germany). LPR was calculated from the highest value of lactate using the following equation (formula OTC Rheinland):

$$\text{highest lactate} - \text{2nd resting lactate}/20 = \text{LPR } (\text{mmol}\cdot\text{s}^{-1})$$

This test was performed in all test days and developed by the Olympic Training Centre Rheinland and the German Taekwondo Union.

Blood sampling

Blood samples for the measurement of blood indicators were taken at all test days. For creatine kinase (CK), capillary blood was taken from the earlobe and measured using the Reflotron® Sprint system Roche Diagnostic, Swiss AG. Venous blood was drawn from the antecubital vein into BD serum vacutainer tube to determine glucose, creatinine, urea and magnesium by a photometric system (Cobas Mira Plus, Roche Diagnostic, Switzerland). Serum concentrations of sodium, potassium, and calcium were analysed by a flame photometry (Efox 5053, Eppendorf AG, Germany).

Psychological measurement

The psychological mood state was analysed using the adjective list for assessing Perceived Physical State (PEPS) [21]. This list covers 4 dimensions, each consisting of 5 adjectives: perceived physical energy (e.g. flabby, washed out), perceived physical fitness (e.g. well trained, strong), perceived physical health (e.g. sick, injured), and perceived physical flexibility (e.g. flexible, elastic). Participants were asked to assess their current physical feeling on all test days (scales: 0 = not at all to 5 = fully).

Statistical analyses

Descriptive statistics was calculated using Microsoft Excel 2010 (Microsoft, USA). All data are presented as means ± SD. To establish main effects of all empirical variables, statistical differences within each intervention and between the interventions were examined. A 2-way (protocol by time) repeated-measures ANOVA with Fisher post-hoc tests was applied using IBM SPSS Statistic software version 20 (GmbH Software, Munich, Germany). Statistical differences were considered to be significant for $p<0.05$. The effect size (ES; Cohen's d) was calculated for the difference between means. Thresholds for small, moderate, and large effects were 0.20, 0.50, and 0.80, respectively [22].

Results

Anthropometry

The body weight showed no significant differences between baseline tests in both RWR and GWR confirming that body weight was restored after each intervention to ensure equal starting conditions (Figure 3A and B). Continuous reduction in body weight was measured daily during RWR and weekly during GWR (Figure 3C and D).

The body weight measurements with BIA confirmed a significant reduction of body weight by 5% in post-tests 1 of RWR and GWR, respectively. Body weight, significantly increased at post-test 2 after RWR and GWR, respectively ($p<0.001$; ES: 0.26, 0.11, respectively). The increase in post-test 2 for GWR was significantly lower than in post-test 2 of RWR ($p=0.001$; ES: 0.18) (Figure 4A).

The body water was significantly reduced after RWR ($p<0.001$; ES: 0.35, 0.40, respectively) and GWR ($p=0.006$; ES: 0.26) but significantly increased again between post-test 2 and post-test 1, respectively (RWR: $p<0.001$; ES: 0.43; GWR: $p=0.032$; ES: 0.09). Significant higher body water was found in post-test 1 of GWR compared to post-test 1 of RWR as well as in post-test 2 of RWR compared to post-test 2 of GWR ($p=0.017$; ES: 0.19, $p=0.028$; ES: 0.14) (Figure 4B).

Differences in body fat were only observed in GWR. Values significantly decreased in post-test 1 compared to pre-tests 1 and 2 ($p=0.008$; ES: 0.56, $p=0.003$; ES: 0.63, respectively). Also, a significant difference in post-test 1 of GWR compared to post-test 1 of RWR was observed ($p=0.009$; ES: 0.22) (Figure 4C). Body fat assessed with Harpenden calliper measurement showed significant decreases only in post-test 1

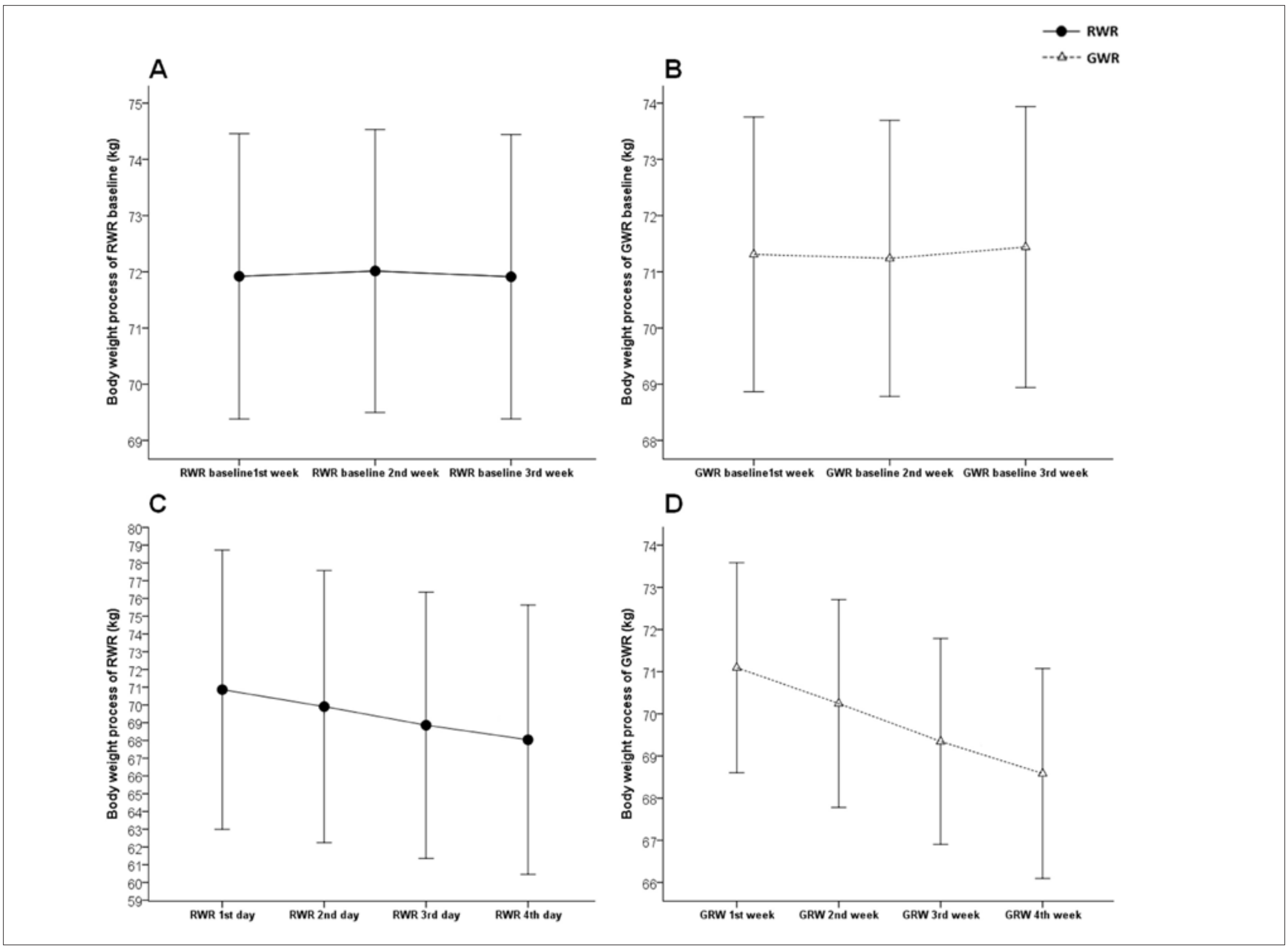

Figure 3 A Body weight measured at baseline tests during RWR. **Figure 3 B** Body weight measured at baseline tests during GWR. **Figure 3 C** Daily changes in body weight during four days of RWR. **Figure 3 D** Weekly changes in body weight during four weeks of GWR. The Data were expressed as mean ± SD.

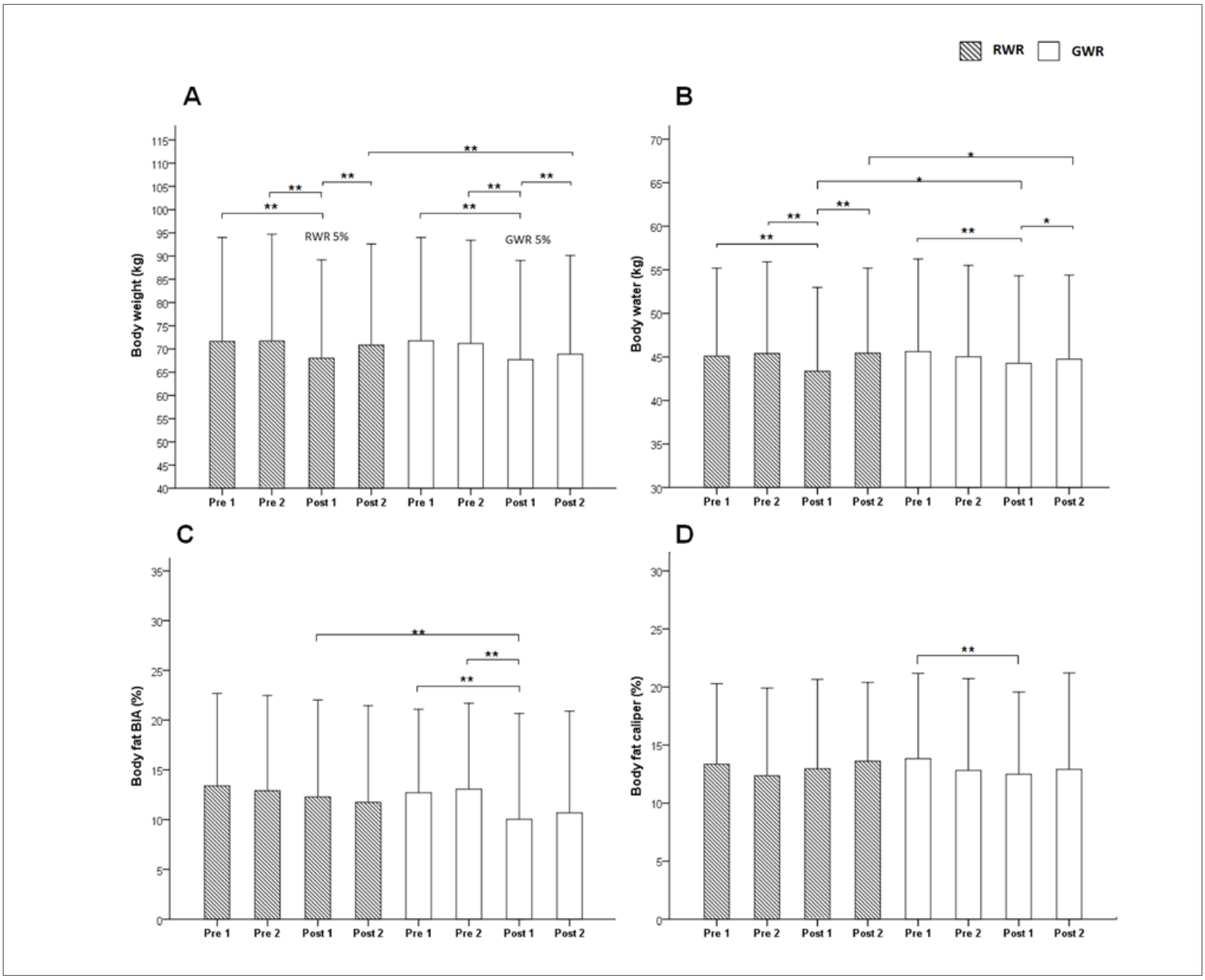

Figure 4 A Body weight in all tests (kg). **Figure 4 B** Body water in all tests (kg). **Figure 4 C** Body fat with the bioelectrical impedance in all tests (%). **Figure 4 D** Body fat with the Harpenden calliper in all tests (%).
Significant differences ($p < 0.05$, ** $p < 0.01$), all values are mean ± SD of 10 subjects.

compared to pre-test 1 of GWR (*p*=0.001; ES: 0.37) (Figure 4D).

Vertical jumps

The evaluation of the vertical jumps revealed that the heights of SJ and CMJ were significantly higher in post-test 1 than in pre-test 1, but only in RWR (*p*=0.035; ES: 0.63, *p*=0.02; ES: 0.51, respectively) (Table 2).

Taekwondo specific performance

The kick-frequencies counted by the investigator showed significant increases only in post-tests 1 and 2 of GWR compared to post-tests 1 and 2 of RWR (*p*=0.005; ES: 1.26, 0.72, respectively). Kick-frequency assessed by the electronic protector was also significantly enhanced in post-tests 1 and 2 of GWR in comparison to post-tests 1 and 2 of RWR (*p*=0.018; ES: 0.95, *p*=0.028; ES: 0.74, respectively). LPR was significantly decreased only in post-test 1 compared to pre-test 2 of GWR (*p*=0.046; ES: 0.54) (Table 2).

Blood indicators

The level of blood glucose was significantly decreased after RWR compared to pre-test situations (*p*=0.011; ES: 1.18 and *p*=0.008; ES: 1.21, respectively) (Table 2). Also after GWR significantly decreased values were observed (*p*=0.028; ES: 1.07). Other examined blood indicators like CK, creatinine, urea and electrolytes were unchanged in GWR. Both, CK and creatinine were significantly higher after RWR (CK: p=0.013; ES: 0.85; creatinine: p=0.045; ES: 0.58 pre-1, p=0.002; ES: 0.90 pre-2). Urea was higher after RWR (p=0.003; ES: 1.13 pre-1, p=0.03; ES: 1.04 pre-2). Significant differences of sodium and magnesium were detected after RWR (sodium: p=0.008; ES: 1.27; magnesium: p=0.011; ES: 1.25 pre-1, p=0.003; ES: 0.93 pre-2, respectively) but no differences were observed in the potassium level (Table 2).

PEPS scales

The lower scale values of physical energy, -fitness, -health and -flexibility significantly changed between post-test 1 and pre-tests 1 and 2 in RWR (p<0.001; ES: 3.02, 3.40, p=0.001; ES: 2.04, p<0.001; ES: 3.41, p=0.026; ES: 0.87, p=0.007; ES: 1.13, p=0.003; ES: 1.84, respectively). Physical fitness value was significantly higher after GWR (p=0.036; ES: 0.88). The same accounts for physical health values (p=0.01; ES: 1.14, p=0.021; ES: 0.75, 0.55, respectively) and physical flexibility (p=0.004; ES: 1.78) (Table 2). Additionally, for all values significantly higher values were achieved in GWR compared to RWR.

Discussion

Athletes of combat sports reduce weight prior to competition in order to fight at the upper limit of the next lighter weight class. Often, rapid weight loss is preferred but accompanied by a loss in athletic performance [5, 6]. In our study, we therefore tested an alternative way to lose weight, compared this to a common method and tested how both methods affect physiological and psychological performance.

The athletes reduced their weight during each intervention by at least 5%, but in RWR, athletes lost weight by loss of water while in GWR athletes lost

Table 2. Vertical jump and Taekwondo specific performance, blood samples and adjective list for assessing Perceived Physical State at different measurement times (all values are presented as mean ± SD).

	RWR				GWR			
Parameters	Pre-test 1	Pre-test 2	Post-test 1	Post-test 2	Pre-test 1	Pre-test 2	Post-test 1	Post-test 2
SJ [cm]	40.9 (2.4)		42.3 (1.7)^{a*}		41.5 (2.7)		42.9 (2.5)	
CMJ [cm]	43.1 (2.0)		44.1 (1.8)^{a*}		43.0 (1.7)		43.9 (2.0)	
Kick frequency	76.5 (5.5)	77.9 (4.8)	75.7 (3.4)	78.6 (3.9)	78.2 (3.0)	82.4 (5.3)	80.9 (4.7)^{c**}	81.4 (3.8)^{d**}
Kick frequency (E)	54.3 (13.9)	59.8 (10.9)	61.3 (5.9)	63.0 (9.2)	62.0 (11.0)	69.9 (8.2)	69.5 (10.6)^{c*}	69.3 (7.8)^{d*}
LPR [mmol·s^{-1}]	0.36 (0.07)	0.36 (0.13)	0.30 (0.07)	0.36 (0.08)	0.31 (0.08)	0.33 (0.14)	0.27 (0.07)^{f*}	0.31 (0.08)
Glucose [mmol·L^{-1}]	5.30 (0.16)	5.46 (0.24)	4.60 (0.20)^{a*,b**}	5.27 (0.18)^{c*}	5.24 (0.09)	5.32 (0.09)	4.83 (0.18)^{f*}	5.30 (0.15)
Creatine kinase [U·L^{-1}]	173.0 (110.9)	194.7 (128.9)	279.6 (137.1)^{a*}	249.7 (119.3)	288.8 (245.4)	223.2 (123.2)	315.4 (300.5)	260.5 (188.6)
Creatinine [mg·dL^{-1}]	1.04 (0.05)	1.03 (0.03)	1.12 (0.03)^{a*,b**}	1.10 (0.02)	1.09 (0.04)	1.17 (0.03)	1.12 (0.04)	1.19 (0.03)
Urea [mg·dL^{-1}]	34.4 (1.96)	34.7 (2.26)	43.2 (2.89)^{a**,b*}	40.6 (3.57)	33.3 (2.76)	30.3 (1.96)	35.0 (2.15)	38.3 (2.87)
Sodium [mmol·L^{-1}]	140.6 (0.49)	141.5 (0.50)	142.5 (0.45)^{a**}	142.3 (0.49)	143.7 (1.02)	143.6 (0.40)	143.2 (0.49)	143.9 (0.37)
Potassium [mmol·L^{-1}]	4.25 (0.11)	4.38 (0.05)	4.20 (0.09)	4.29 (0.07)	4.40 (0.07)	4.36 (0.09)	4.29 (0.13)	4.39 (0.07)
Calcium [mmol·L^{-1}]	2.42 (0.02)	2.38 (0.01)	2.38 (0.01)	2.35 (0.01)	2.40 (0.01)	2.37 (0.01)	2.39 (0.02)	2.36 (0.01)
Magnesium [mmol·L^{-1}]	0.83 (0.02)	0.86 (0.02)	0.93 (0.02)^{a*,b**}	0.90 (0.02)	0.94 (0.01)	0.89 (0.02)	0.88 (0.02)	0.91 (0.01)
Physical energy scale	3.28 (0.63)	3.56 (0.63)	1.02 (0.85)^{a**,b**}	2.94 (1.07)^{c**}	3.02 (1.20)	3.94 (0.82)	3.92 (0.91)^{c**}	3.76 (0.88)^{d**}
Physical fitness scale	3.04 (1.01)	3.64 (0.58)	1.12 (0.87)^{a**,b**}	3.16 (0.72)^{c**}	3.20 (0.81)	3.90 (0.57)	3.88 (0.73)^{e*,c**}	4.00 (0.79)^{d*}
Physical health scale	3.36 (0.75)	3.90 (0.80)	3.06 (1.10)^{b*}	3.36 (0.92)	3.14 (1.18)	3.62 (0.99)	4.30 (0.82)^{e**,f*,c*}	3.82 (0.91)^{g*,d*}
Physical flexibility scale	3.18 (0.66)	3.58 (0.41)	2.28 (0.91)^{a**,b**}	3.02 (0.95)^{c**}	3.10 (0.84)	3.44 (1.06)	3.70 (0.67)^{c**}	3.68 (0.69)

RWR: rapid weight reduction; GWR: gradual weight reduction; SJ: squat jump; CMJ: countermovement jump; (E): electronic protector; LPR: lactate production rate.

Procedure main effect: compared to a: pre-test 1 RWR, b: pre-test 2 RWR, c: post-test 1 RWR, d: post-test 2 RWR, e: pre-test 1 GWR, f: pre-test 2 GWR, g: post-test 1 GWR; $*p < 0.05$, $**p < 0.01$.

weight by loss of body fat. The body fluid loss in RWR was caused by the subjects` used methods including energy restriction, higher training intensity and training sessions, fasting and dehydration as also described by other groups [10, 12]. Dehydration as little as 2% can impair physiological responses and performance [23, 24]. The fluid loss of RWR can entail a decrease in plasma volume and blood circulation. These induce a decline in blood pressure, increased resting-and training load heart rate and decreased stroke volume [10]. Consequently, rapid dehydration during RWR phase can lead to athlete's death in extreme cases [25]. A rapid rehydration of fluid intake can restore the general physiological demands [9]. In our study, athletes had a recovery time of approximately 24h from the weigh-in until the simulated competition day. The recovered body weight after RWR was enabled by the fluid intake after the weigh-in and no further problems occurred after restoration of the fluid balance. Though, the actual recovery time of TKD athletes is 18-20h which may lead to an incomplete recovery of fluid homeostasis because this takes about 24-48h and abovementioned problems may occur on the competition day [10].

The fluid loss in RWR did not impair jump height but in contrast, the heights of SJ and CMJ were increased. This acute effect was also observed by Viitasalo [26] and explained by the fact that the ability of neuronal muscular system for the activation of dynamic and static force is not impaired by the body fluid loss of 8% [26, 27]. Significant improvements of kick-frequencies were observed only during GWR compared to RWR. This could be explained either by a learning effect during the test procedure or by a better psychical condition of the athletes after GWR compared to RWR. Therefore, it can be assumed that RWR triggered a feeling of weakness due to the dietary restriction and extra high training sessions with the thermal clothing as also seen by Finn et al. [28] and Nieman et al. [29].

According to the kick-frequency, the result of LPR was tendentiously changed, but no other significance was found due to the high variance although only one significance between pre-test 2 and post-test 1 of GWR was recorded.

Performances may also be influenced by impairments of physiological metabolism. Clearer decrease of blood glucose was indicated after RWR than after GWR (Table 2). Artioli et al. [5] confirmed a decrement of blood glucose during 5-7 days of weight loss, which may lead to an acute hormonal imbalance. Probably, hypoinsulinaemia, increased growth hormone and cortisol concentration can be triggered by hypoglycaemia [13, 30]. Significant increased levels of CK, urea, creatinine and electrolytes were found after RWR. High CK-level may be explained by the increased training intensity and load during RWR. This could induce a damage of muscle tissue and may lead to overtraining and higher risk of injuries if the muscle weakness occurs during the preparation of the competition or on competition day [31, 32]. High CK-levels can also be caused by dehydration prior to TKD-training during RWR because the hydration status influences CK-level. This may facilitate damage of Z-band muscle fibres [33]. Moreover, increased urea can induce imbalances in protein metabolic homeostasis, a high protein catabolism that cause tissue damage and fatigue from exercise. The rise in ammonia during higher training intensity after RWR infers from the first area of the purine nucleotide cycle catalysed by adenylate deaminase, which occurs in all muscle fibres relating to the intensity of the metabolic stress and glycogen availability [13, 34]. According to Sahlin et al. [35] the reduced muscle glycogen availability impairs ATP resynthesis and induces AMP accumulation and ammonia production. Further, increased values of creatinine occurred during RWR due to dehydration and decrease of muscle tissue that was also shown in several studies after hypocaloric diet [36, 37]. As a consequence, performance may decline in the course of several fights on the competition day.

Electrolytes such as sodium and magnesium were significantly increased in RWR due to hypohydration. This imbalance impairs the action potential for the muscle contraction which can induce muscular fatigue [9, 11]. In contrast thereto, no changes of electrolytes were observed after GWR. This effect indicates that above-mentioned physiological impairments can be avoided by GWR prior to competition.

GWR showed definite benefits of physiological and psychological performances and lead to improvement of TKD-performance without impairments of blood parameters and psychological mood states. Thus, GWR is required for athletes and trainers to implement in the praxis in order to avoid a decrease in performance prior and during competition.

Conclusion

The findings of the present study showed that RWR is less suitable prior to competition compared to GWR. The lowered kick-frequency in RWR was caused by rapid loss of body fluid but also, psychological aspects can still reinforce this effect, which may induce the detrimental decline of the performance on the competition day. The GWR period proved overall better findings as well as an increase in kick-frequency, blood indicators and psychological mood state. For this reason, trainers and TKD athletes should educate about the adverse consequences of this short-term fasting and dehydration on physiological and psychological condition and performance. In respect thereto, the GWR should be planed as a better method of weight reduction for an optimal competitive preparation of the TKD athletes and to avoid a potential decline of the performance in the course of several competitions.

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Competing interests

The authors declare that they have no competing interests.

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