

The effect of conventional methods of body weight reduction on overall sense of well-being, body composition and anaerobic capacity of athletes practicing selected combat sports

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Summary

Introduction. Body weight reduction (BWR) is a common practice in combat sports. However, athletes typically prefer rapid BWR methods. For this reason the aim of this study was to assess the effect of conventional body weight reduction methods on selected indices in athletes practicing combat sports.

Material and methods. The study involved 23 male athletes practicing boxing and wrestling. The 4-day energy balance of athletes was assessed based on the dietary recording, as well as daily energy expenditure. The effect of BWR on anaerobic capacity was analyzed using the Wingate test, while body composition was assessed by electric bioimpedance. The characteristics of BWR and its effect on the overall sense of well-being were determined based on the questionnaire developed by the authors.

Results. In order to obtain BWR athletes first of all limited their consumption of food and fluids. This could have led to the occurrence of declared ailments, such as confusion, deterioration of the overall sense of well-being, depression and dizziness. Energy deficit during BWR resulted in a reduced fat mass (-1.1 kg), fat free mass (-1.9 kg) and body water (-1.2 L). Following BWR a significant decrease was also observed in peak (-82.5 W), average (-32.5 W) and minimal power (-19.3 W), as well as an extension of time to reach peak power (+1.5 s).

Conclusion. Athletes practicing combat sports use methods facilitating rapid BWR, which unfortunately has an adverse effect on their overall sense of well-being, body composition and anaerobic capacity.

Introduction

Boxing and wrestling are these sports discipline, in which being assigned to a given weight class may determine the final results of athletes. Competition with an opponent belonging to a lower weight class potentially makes it possible to gain physical advantage, thus in combat sports pre-competition body weight reduction (BWR) is typically practiced, which in terms of its intensity may be defined as rapid weight loss (RWL) or gradual body weight reduction (GWR) [1-3]. In relation to the BWR volume it was shown that a considerable percentage of athletes reduce their body weight by 5-10%, while some respondents declared weight reduction of more than 10% [2-8], additionally starting the body weight reduction period as late as a week before the competition [2,9-10]. Literature sources describe such extreme cases as those when

a week-long RWL amounted to as much as 18.1% [11], whereas the first body weight reductions were already observed in children aged 5 years [12]. What is more, cases were also reported, in which RWL led to the death of the athlete [13-14]. However, it needs to be mentioned here that BWR might bring certain advantageous effects if it was executed in a rational manner [6,15]. Moreover, in a study by Pattersson et al. [4] it was found that pre-competition BWR is perceived by athletes as an important element in mental preparation for a fight, enhancing the feeling of control, commitment and thus self-assurance. Unfortunately, athletes frequently habitually adopt inappropriate BWR methods, involving e.g. fasting, limited fluid intake, long-term sauna sessions and training in impermeable clothing [1-2,5,9]. It seems that in many cases athletes are not aware that such a rapid body weight loss (RWL) results mainly from dehydration and reduced muscle and hepatic

glycogen resources, which eventually limits exercise capacity [16], e.g. due to the impaired thermoregulation, water-electrolyte imbalance [13] and reduced maximum oxygen uptake (O_{2max}) [17], strength [18] and endurance, as well as plasma and blood volume [19]. Both in boxing and in wrestling the specific character of exercise requires also an effective supply of energy through anaerobic metabolism [8,20-22], which effectiveness may be disturbed by RWL [20]. Additionally, rapid-BWR may have a negative effect on mental functions, causing mood swings, impaired memory, attention concentration and cognitive functions [2,5,23-25], which seems to directly reduce the chance for success in sports.

The frequent use of rapid-BWR by athletes may be connected with a lack of proper education concerning rational BWR, resulting e.g. from the insufficient number of studies in this field. For this reason it seems necessary to conduct further research in this respect, required for the practical application of recorded results and a change in BWR methods adopted in the pre-competition period. In view of the above the aim of his study was to assess the effect of conventional body weight reduction in athletes practicing boxing or wrestling on the overall sense of well-being, body composition and anaerobic capacity.

Material and methods

Subjects

The study involved 23 male athletes practicing boxing and wrestling in sports clubs from the Wielkopolska region (Table 1). Criteria for the participation in the study included fulfilling requirements concerning good health condition, having a valid currently issued medical certificate confirming their capacity to practice sports, performance of min. 4 boxing and wrestling training units a week and at least a 4-year training period. The specific character of physical exercise (targeted and supplementary training sessions) were very similar in all participants.

Procedures

Identical experimental procedures were applied at two stages at the Laboratory of Exercise Tests, the Poznan University of Life Sciences: in the first (control) phase (BWR_{PRE}), with no body weight modification (5 days) and in the second, pre-competition period – during and after body weight reduction (BWR and BWR_{POST}, 5-14 days), applying the method typically selected by athletes. Additionally, during the first experimental series in the control period the regression dependence was established for $VO_2 \cdot HR^{-1}$. All the tests were performed under constant measurement conditions (in the morning hours, at a temperature of 20-23°C).

In accordance with the Declaration of Helsinki all the participants expressed their free and conscious consent to participate in research procedures [26]. The consent of the Bioethics Committee at the Karol Marcinkowski University of Medical Sciences in Poznan was granted for the performance of

these tests (decision no. 981/12 of 8 November 2012). It also needs to be stressed here that the authors of this study did not give their consent to any other actions or methods to reduce body weight, which may be connected with any health hazard or be inconsistent with anti-doping regulations of the World Anti-Doping Organization (WADA) Code.

Measures

Body composition

Body mass and height were measured using a WPT 60/150 OW RADWAG® medical anthropometer (Poland). Body composition was measured using electric bioimpedance with a BIA 101S analyzer by AKERN-RJL (Italy) and the Bodygram 1.31 computer program (AKERN-RJL, Italy). Body composition was analyzed strictly following recommendations [27] for measurement conditions.

Anaerobic capacity

The level of anaerobic capacity was assessed using a Monark 894E cycloergometer (Sweden) following the protocol proposed by Bar-Or [28]. The participants started from a 5-minute warm-up of 50 W power, followed by a 5-minute rest and then performed a classical 30-second Wingate test. External loading was adapted individually at 7.5% body weight. During the test the athletes were encouraged to maintain maximum exercise. Recorded data were analyzed using Monark Anaerobic Test Software (ver. 3.0.1, 2009).

Evaluation of diet

The diet was evaluated using a 4-day ongoing recording [29] with the use of the Album of Photographs of Food and Dishes [30], together with an original questionnaire concerning lifestyle, eating habits and training characteristics, which made it possible to determine the specific character of pre-competition body weight reduction in athletes, conducted based on conventional limitations and dietary modifications as well as other methods of body weight reduction. Athletes were acquainted with the correct method to record and register diet data. Total caloric value of the diet (TCV) was calculated based on the results and using the computer data base prepared in the Dietetyk 2 program (Poland). The calculations included basic cooking and technological losses.

Energy expenditure

Total daily energy expenditure (TDEE) was established using POLAR RS400 heart rate monitors (Finland). Heart rate (HR) was recorded continuously for 4 days. In order to detect possible measurement errors athletes simultaneously recorded all performed activities. Next the data from the wrist monitoring device were transferred using an interface coupled to a computer with the Polar ProTrainer ver. 5 software (Finland). In order to calculate TDEE the regression analysis was performed for $VO_2 \cdot HR^{-1}$ – individually for each athlete using a Cosmed K4b² ergospirometer (Italy). Next the heart rate threshold was determined at HR-FLEX. Following the recom-

mended procedure [31] the recorded HR values, depending on the level of physical exercise, were converted to energy expenditure under free living conditions.

Statistical analyses

Statistical analyses were conducted using the Statistica 9.0 software package by StatSoft (Poland, 2011, license no. JGNP006B037802AR-9). In order to verify whether the random sample came from a population with the normal distribution the Shapiro-Wilk test was performed. Significance of changes in the tested indexes between the control and pre-competition periods (BWR_{PRE} vs. BWR_{POST}) was evaluated at the significance level of 95%. Basic descriptive statistics were calculated for the recorded parameters for individual periods and arithmetic means together with their standard deviations (\pm SD) were compared using the t-Student test for dependent samples.

Results

Data concerning characteristics of the tested group of athletes are presented in Table 1. The length of targeted training units of combat sport (boxing or wrestling) within a week was on average 7.8 ± 1.6 h·week⁻¹. The mean declared age, at which athletes for the first time reduced body weight before competitions was 15.5 years of age, while BWR conducted within this study was less than 7.5 ± 3.0 days (Table 1).

Each of the study participants in the pre-competition period used the most common methods of body weight reduction, i.e. increased physical activity and reduced caloric value of the diet, leading to a markedly negative energy balance, mainly by limiting the intake of fats (~90%) and carbohydrates (~75%), as well as cutting down on products rich in these nutrients. Moreover, the participants reduced their intake of fluids (~70%) and at the same time used sauna sessions (thermal dehydration) or exercised in impermeable clothing (exercise dehydration). None of the athletes, despite physical activity during BWR consumed more than 4 L fluids·day⁻¹, while 2 individuals declared fluid uptake below 250 ml·day⁻¹ (Table 2).

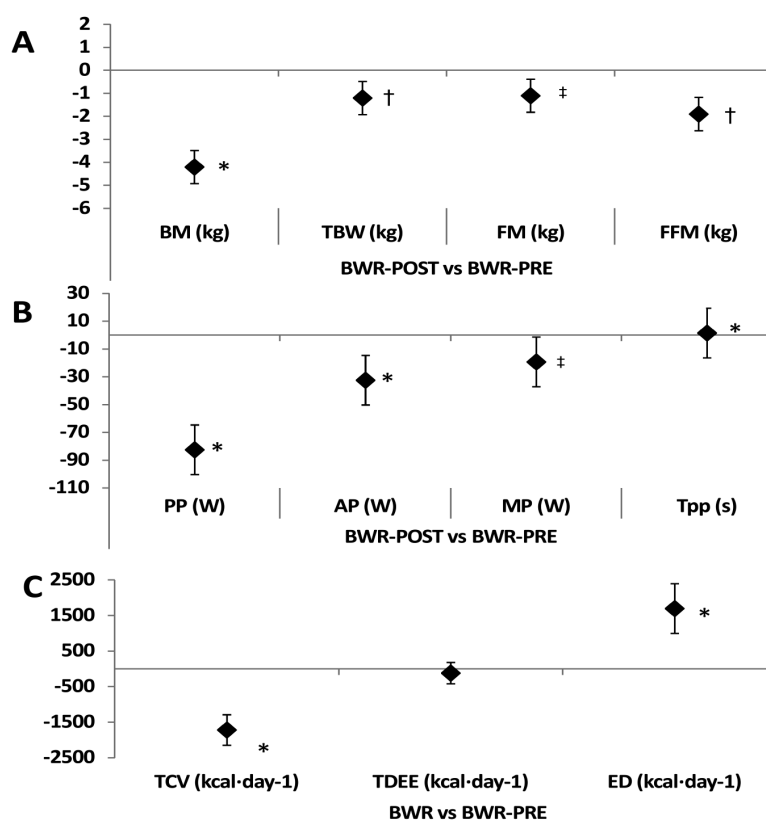
Table 1. Basic data and characteristics of selected indexes defining body composition and weight, anaerobic capacity and energy balance in athletes practicing boxing and wrestling during the control period (BWR_{PRE})

Variable	Unit	BWR _{PRE}	
		$\bar{X} \pm SD$	Range
Age	(years)	20.1 \pm 4.3	15-28
Height	(cm)	178 \pm 7.8	158-189
LTU	(h·week ⁻¹)	7.8 \pm 1.6	5-10
Age at 1st BWR	(years)	15.5 \pm 3.3	12-23
Duration of BWR	(days)	7.5 \pm 3.0	4-14
BM	(kg)	76.1 \pm 13.3	48-102
TBW	(%)	61.9 \pm 2.2	57-65
FM	(%)	15.5 \pm 3.0	12-23
FFM	(kg)	64.3 \pm 9.3	42.7-79.6
PP	(W)	877 \pm 203	462-1389
AP	(W)	577 \pm 120	312-852
MP	(W)	363 \pm 79.9	190-534
T _{pp}	(s)	2.2 \pm 1.3	1.2-5.3
TCV	(kcal·day ⁻¹)	3289 \pm 992	3055-4782
TDEE	(kcal·day ⁻¹)	3574 \pm 964	1386-4327
ED	(kcal·day ⁻¹)	285 \pm 463	0-2359

LTU – length of targeted training units, BM – body mass, TBW – total body water, FM – body fat, FFM – free fat mass, PP – peak power, AP – avg. power, MP – min. power, T_{pp} – time to peak power, TCV – total caloric value, TDEE – total daily energy expenditure, ED – energy deficit

Table 2. Practices aiming at BWR and declared overall sense of well-being during BWR in the examined group of athletes [%]

BWR method	$\bar{X} \pm SD$ (%)
Increased physical activity	100
Considerable reduction of food consumption	100
Considerable reduction of fat uptake	90 \pm 0.3
Considerable reduction of carbohydrate uptake	75 \pm 0.4
Limitation of fluid consumption	70 \pm 0.5
Sauna/exercise in impermeable clothing	70 \pm 0.5
Pharmaceuticals, diuretics	0
Declared overall sense of well-being during BWR	$\bar{X} \pm SD$ (%)
Confusion	75 \pm 0.4
Deterioration of overall sense of well-being, depression	70 \pm 0.5
Headaches	50 \pm 0.5
Nausea	45 \pm 0.5
Dizziness	40 \pm 0.5



, †, ‡ - significant differences in comparison to BWRPRE (- $p < 0.001$, † - $p < 0.01$, ‡ - $p < 0.05$)

BWRPRE: "training period" (before body weight reduction); BWRPOST: "pre-competition period" (after body weight reduction); BM: body mass; TBW: total body water; FM: fat mass; FFM: fat free mass; PP: peak power; AP: average power; MP: minimal power; Tpp: time at PP; TCV: total calorific value; TDEE: total daily energy expenditure; ED: energy deficit

Figure 1. Analysis of differences after BWR in (A) body mass and body composition, (B) anaerobic capacity determined based on the Wingate, and (C) changes in energy balance during BWR

Athletes in the original questionnaire developed for this study also described their overall sense of well-being during body weight reduction. The most frequent ailments included confusion (~75%) and deterioration of the overall sense of well-being as well as depression (~70%). Slightly less often athletes complained of headaches, nausea and dizziness (Table 2).

Following the body weight reduction (BWR_{POST}), simulating the pre-competition period, body weight reduction was on average 4.2 ± 1.1 kg, which constituted over 5,5% initial body weight of athletes. BWR resulted mainly from the reduction ($p < 0.01$) of fat free body mass (-1.9 kg) and body water (-1.2 L), and not only fat mass (-1.1 kg; $p < 0.05$) (Figure 1A).

In turn, analysis of anaerobic power indexes showed that the most frequently applied BWR methods resulted in a considerable reduction of peak (-82.5 W; $p < 0.001$) and average (-32.5 W; $p < 0.001$) power as well as minimal power (-19.3 W; $p < 0.05$). A considerable extension was also observed (+1.5 s; $p < 0.001$) for the time required to reach peak power (Figure 1B).

The diet and total daily energy expenditure showed that athletes considerably reduced ($p < 0.001$) the consumption of food and fluids during BWR, at the same maintaining the pre-

vious level of physical activity, which led to an increased ($p < 0.001$) energy deficit (ED) by $1698 \text{ kcal} \cdot \text{day}^{-1}$ (Figure 1C).

Discussion

Athletes initiating BWR at a young age are at a greater risk of the declared ailments connected with body weight loss than athletes starting this practice at an older age [13]. For this reason the age, at which athletes for the first time start pre-competition making weight, is particularly disturbing. Some participants in this study declared the first BWR already at the age of 12 years, while the average was at 15.5 years of age. A similar age was reported in judoists [1], who practiced BWR starting already at 12.6 years of age. In turn, in wrestling [32] and taekwondo [2] the mean age at the first BWR was reported to be 14-15 years. Additionally, in most cases athletes start body weight regulation as late as a week before competitions [2,9-10], which was also observed in this study, in which the selected group of athletes started BWR on average 8 days (from 5 to 14 days) before tests in the BWR_{POST} period. It needs to be stated that such a body weight reduction,

amounting to 4,2 kg within 8 days, is equivalent to an average of 1 kg per 2 days and may be definitely considered rapid and against the assumed rational recommendations [15-16,33].

In order to make weight so rapidly, athletes practice different methods (Table 2) modifying their daily energy requirement, i.e. they increase their physical activity, follow low-calorie diets, limit or completely eliminate carbohydrates and/or fats, or induce dehydration by limiting fluid intake and at the same time use the sauna or wear impermeable clothing. The application of these methods was also confirmed in studies by other authors [1-2,6,13]. Additionally, they also show [2,34] that in combat sports other irrational and frequently dangerous methods are also used, such as induced vomiting, administration of certain dietary supplements and pharmaceuticals (e.g. laxatives and diuretics), which however was not observed in this study. This may have resulted from the fact that the athletes were strictly warned against such practices by the authors of the study, who did not agree to any actions or BWR methods, which could constitute a health hazard or infringement of antidoping regulations.

Valuable observations concerning the effect of conventional BWR methods practiced by the tested group of athletes were also provided by the subjective evaluation of their overall sense of well-being and ailments accompanying the making weight process. Athletes generally believe that body weight reduction, conducted for several days before the competition is easier to accept than longer periods of dietary deprivation. However, this study showed a considerable negative effect of RWL on their psychophysical state, as well as frequently experienced pain and dizziness as well as nausea. The above observations correspond with studies, in which it was also shown that rapid body weight reduction has a negative effect on the psyche and exercise capacity e.g. by increasing central fatigue, irritability and aggression, as well as disturbed cognitive functions and mood deterioration, even resembling symptoms of depression [2,5,23-25].

Numerous studies also showed that combat sports athletes follow low-calorie diets to reduce body weight before competitions [1-2,5-8,13,35], which was also observed in this study, in which additionally the uptake of energy was assessed jointly with energy expenditure of athletes under free living conditions. The athletes participating in this study during BWR maintained a comparable physical activity as in the control period, while their TCV decreased significantly ($p < 0.001$, Figure 1C). They supplied over 50% less energy during BWR in comparison to the BWR_{PRE} stage. It was observed that energy uptake of the participants both in the preparation (training) period and in the pre-competition period was lower than their energy expenditure, although the energy deficit during BWR was by as much as 1698 kcal greater than in the BWR_{PRE} period (285kcal). A slightly lower energy deficit in the pre-competition period, i.e. 1246 kcal·day⁻¹, was reported by Drummond et al. [35] in a study conducted with the participation of taekwondo fighters. However, it needs to be stressed that such a considerable reduction of food and fluid consumption may lead to excessive degradation of muscle proteins, dis-

turbed post-exercise regeneration and as a consequence an increased risk of overtraining and impaired muscle exercise capacity [2,13,16,18-19]. Probably the highly negative energy balance was a decisive factor in the reported adverse changes in body composition of athletes, using rapid body weight reduction, which was reported during RWL also in a study by Yang et al. [6] involving taekwondo fighters and by Coufalova et al. [36] in their study involving judoists.

What is more, both in boxing and wrestling the specific character of exercise requires an effective supply of energy via anaerobic metabolism [8,20-22], thus any disturbance in this metabolism may directly reduce power, speed and dynamics of athletes [20]. It is essential, since during a fight the effectiveness of a series of attacks with supramaximal intensity may determine the final sports success. Additionally, the immediate effect on the deterioration of anaerobic capacity is also exercised by certain consequences of rapid-BWR such as depletion of muscle glycogen reserves, limited capacity to buffer the acid-base imbalance and water-electrolyte imbalance [16]. Moreover, it needs to be stressed that the observed lack of potential rehydration and nutritional rehabilitation after pre-competition weigh-in of athletes to a significant degree contributes to a further decrease in anaerobic capacity [37-38]. The interval between the official weigh-in and participation in a competition may last from several to around a dozen of hours, thus in the case of a longer period the body may have a chance for some regeneration; however, if this period is shorter than 4 h, regeneration may not be effective. Results recorded in this study (Figure 1B) indicate that the conventional methods of body weight reduction, which may definitely be called rapid, clearly cause a considerable reduction of anaerobic capacity in athletes practicing boxing and wrestling. Also a study by McMurray [37] showed that rapid body weight reduction due to the insufficient carbohydrate intake causes a significant decrease ($p < 0.05$) of anaerobic capacity in athletes practicing wrestling (PP: -7% and AP: -6%). These observations are also confirmed by studies, in which the level of anaerobic capacity decreased after BWR in athletes practicing combat sports, although adaptation changes were assessed in those studies using other methods than the Wingate test [3,38-39].

Summing up, it seems that many coaches and athletes in combat sports still treat rapid BWR as a typical element in the preparation strategy before competitions [4]. For this reason it seems necessary to implement in this group adequate education, making it possible for athletes and their coaches to properly plan a rational program [15-16,33] for body weight reduction, connected first of all with a reduction of fat mass, which may contribute to minimization of negative effects of consequences of rapid-BWR, or even an increase in exercise capacity [40-41]. Athletes using rational body weight reduction may gain thanks to the increase [41-42] in the ratio of active muscle mass to the adipose tissue, which contributes to an increase in power, strength and speed, as well as dynamics and endurance, which in comparison with athletes competing in their natural weight class or rapidly reducing their body weight may determine the final result of their fight.

Conclusions

1. Athletes practicing boxing and wrestling typically practice rapid methods of body weight reduction, connected e.g. with a considerable reduction in energy uptake from the diet.
2. Rapid body weight reduction has an adverse effect leading to a greater reduction of fat free mass and total body water than the decrease in fat mass.
3. Rapid body weight reduction has a negative effect on anaerobic capacity of athletes, reducing their anaerobic power and extending the time required to reach peak power.

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