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The effects in humans of rapid loss of body mass on a boxing-related task

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Abstract The physiological effects of strategies for a rapid loss of body mass immediately before weighing in for competition in weight-governed sports are unclear. This study examined the effects of a 3%–4% loss in body mass on a boxing-related task. Seven novice amateur boxers completed three 3 min rounds of simulated boxing on a prototype boxing ergometer in an euhydrated state (E-trial) and after exercise-induced thermal dehydration (D-trial). All subjects lost body mass following dehydration—mean body mass fell 3.8 (SD ± 0.3)% [77.3 (SD ± 11.3) to 74.4 (SD ± 10.7) kg, \( P < 0.001 \)]—but changes in plasma volume (PV) were inconsistent. Four subjects suffered reductions in PV between 15% and 30%, one subject maintained his E-trial value and two recorded an increase. The D-trial mean PV value was 8.0 (SD ± 17.2)% lower but this fall was not statistically significant \( P > 0.05 \). Analysis of D-trial boxing performance showed one subject maintained his performance over the two trials and a second improved 17.8%. A two-way ANOVA (condition \( \times \) time) with repeated measures on both factors showed no significant main effect differences for condition \( (F_{1,6} = 3.93, P > 0.05) \), time \( (F_{1,83,48} = 1.12, P > 0.05) \) or interaction between them \( (F_{1,93,48}, P > 0.05) \). Furthermore, neither heart rate nor blood lactate responses in the boxing task differed between trials. These data were affected by the small sample. Power and effect size analysis using \( n^2 \) procedure and removing the outlier data produced a mean fall in boxing performance of 26.8%. However, some subjects appeared able to resist the deleterious effects of a rapid loss of body mass prior to competition and further research is needed to explain the mechanisms underpinning this ability.

Key words Anaerobic · Boxing · Ergometer · Weight loss · Plasma volume

Introduction

An amateur boxer is an athlete who competes in a class which limits the maximal permissible body mass. Such boxers have been reported to manipulate their body masses prior to competition to gain physiological and psychological advantages over fellow competitors (Jako 1986). In the 7 days preceding international competition a reduction in body mass of about 5% has been reported as common, with some boxers losing as much as 4% in the 3 h leading up to the official weigh-in (Smith 1998). These reductions are usually achieved through fluid loss which may not always be replaced in the period between the weigh-in and the actual bout. Evidence has been produced showing deleterious effects of body fluids loss on aerobic performance (Craig and Cummings 1966; Caldwell et al. 1984; Armstrong et al. 1985; Klingzing and Karpowicz 1986). Post-competition blood lactate concentrations \([\text{La}^-]\) ranging from 6.34 to 17.71 mmol \( \cdot \) L\(^{-1} \) have been reported in elite international boxers (Smith 1998) but the effects of such loss on strength, power and anaerobic performance are equivocal (Bosco and Terjung 1968; Torranin et al. 1979; Jacobs 1980; Houston et al. 1981; Viitasalo et al. 1987; Webster et al. 1990; Hickner et al. 1991).

It has been suggested that the equivocal nature of these reports may have been due to the lack of sufficiently specific methods for evaluating sporting performance (Davids 1988). The aims of this study were to improve the validity of a simulation of a boxing task through the development of a prototype boxing ergometer, and to use the device to investigate the effects of a rapid 4% reduction in body mass on simulated boxing performance.
Methods

Subjects

Eight members of the College’s Men’s Boxing Club volunteered to take part in a cross-over design study having given informed consent and been reminded that they had the right to withdraw from the project at any time. The experiment protocol was approved by the Ethics Committee of the Faculty of Sciences of University College Chichester. One subject withdrew from the study before completing the second trial; the mean age, height and mass of the remaining seven subjects were 20.4 (SD ± 0.9) years, 1.80 (SD ± 0.4) m and 77.3 (SD ± 12) kg, respectively. They were technically adept in boxing but inexperienced in procedures for rapid body mass loss.

The boxing ergometer

A mechanical boxing ergometer was constructed. An adjustable target pad (MK Sports International, Roehdale), made from reconstituted foam and covered in full grain hide, was attached to a piece of steel conduit which pivoted around its base. A Radio Spares (RS) 6 V DC Precision Motor linked the pivoting arm to a weight stack by a system of chain-driven pulleys. When the pad was struck an electrical signal was generated which was proportional to the height the weight stack was raised. This signal was relayed to an Archimedes Computer sampling at 50 Hz. The signal amplitude was given a value of between 0 and 1250 arbitrary units. A threshold value of 300 was set to prevent recordings of a rebound effect when the weight stack returned to its starting position. The output of each 10 s of punching activity equaled the sum of voltages generated over that time and was called a “burst unit”.

To calibrate the device a rig was constructed consisting of a freely swinging T-shaped pendulum suspended from the top of a scaffold platform. A Bryan competition glove (284 g) was fixed at one end of the horizontal arm; weight-lifting discs of different masses could be attached at the other. The mass of the pendulum without extra weights was 4.8 kg. The pendulum was released from a fixed distance of 50 cm from the padded target simulating a single straight punch. Six discs with masses of 15.3–39.7 kg produced a range of punching forces. Infra-red light gates (RS Transmitter 348–201 and Receiver RS 348–194) were positioned on the scaffold to record the time taken for the final 0.024 m of the pendulum’s path before contact with the target. Six trials were conducted with each disc.

The performance task

A simulated bout was performed under two conditions, an euhydrated state (E-trial) and following exercise-thermal dehydration (D-trial); the order was randomised. A 7 day recovery period was given between trials. Subjects were habituated to the task prior to the experiment and were encouraged to make their best effort on each punch.

The subjects completed three rounds, each 3 min long and consisting of 18 repetitions of a 9 item activity delivered by audiotape. A 1 min seated recovery occurred between rounds. A total of 108 punches per round were thrown. This has been reported as being consistent with the average number of punches thrown during analyses of international competitions from Commonwealth Games and World Senior Championships over a range of weight categories (Smith 1998). The activities included straight punches with lead and rear hands aimed at a cross placed at shoulder height on the target, and stepping into and away from the ergometer.

Physiological measurements

In both trials the subjects entered the laboratory in a rested, euhydrated state, having been instructed to maintain a normal fluid and energy intake for the preceding 48 h. Nude body mass (mN) was determined prior to each trial on scales (Avery Birmingham, England) calibrated to ± 0.05 kg. A 50 µl blood sample was taken by thumb-prick in a standing position to determine pre-exercise haemoglobin concentration [Hb] and haematocrit (Hct) (Coulter Counter M5 30), and resting [La–]b (Roche 640 Lactate Analyser).

For the D-trial subjects were required to reduce body mass by 3%–4%. Chemical warfare clothing (Royal Navy, Ministry of Defence), comprising hooded plastic top and bottoms, were worn beneath a tracksuit. The subjects cycled at a power output of 60 W for 25 min, followed by a 5 min recovery, in an environmental chamber set at an ambient temperature of 40 °C. The relatively low power output was designed to induce dehydration whilst minimising the effects of glycogen depletion. After an hour each subject left the chamber to check the extent of weight loss. They returned to the chamber until mN had been reduced by at least 3%. No fluid intake was allowed during the dehydration process. The mean time spent in the chamber was 116 (SD ± 21) min. Each subject then cooled down by showering. They were re-weighed and a second 50 µl blood sample was taken by thumb-prick in the standing position to determine post dehydration [Hb] and Hct. Changes in plasma volume (PV) were estimated using the equations reported by Dill and Costill (1974).

Heart rates (fH) were recorded using a PE 3000 Sports Tester (Polar Electro, Finland) every 15 s throughout the bout. Crepe hand bandages (2.5 m length, 5 cm width) were worn by each subject underneath Bryan competition gloves weighing 284 g each. A 15 min self-selected warm-up comprising jogging, stretching, and striking hand held coaching pads was conducted prior to the bout simulation. This elevated heart rates to 135–145 beats·min⁻¹. A 50 µl blood sample was drawn by thumb-prick 4 min post performance in the standing position to determine [Hb], Hct and [La–]b and any changes in PV.

Statistical procedures

Two-way ANOVA (condition × time) with repeated measures on both factors examined changes following each bout under both conditions. Post-hoc Tukey procedures were used to examine significant differences. Pearson product-moment correlations examined the relationships between variables.

Results

Ergometer calibration

The signal amplitude (mV) and time (ms) over the final 0.024 m for each of the conditions is shown in Table 1. The within trials coefficients of variation ranged between 0.2%–2.7% and 0.3%–0.7%, respectively. Linear regression analysis of the data (y = 23.135x – 46.93) showed a strong positive relationship (r² = 0.96; P = 0.005) between mass and signal amplitude.

Boxing performance

A two-way ANOVA (condition × time) with repeated measures on both factors examined changes in boxing performance during each bout simulation in the E-trial and D-trial. No main effect for condition (F(1,6) = 3.93, P > 0.05), time (F(3,18,48) = 1.12, P > 0.05) or the interaction between condition and time (F(3,18,48) = 1.64, P > 0.05) was evident (Fig. 1).