The effects of hydration and aerobic fitness on physiological strain and endurance performance

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Introduction. Despite the widely accepted notion that dehydration of 1-2% body mass impairs endurance performance, there is no convincing evidence that athlete performance is suboptimal when fluid is consumed *ad libitum*; a rate that typically causes hypohydration of ≥ 2%. Regular endurance training stimulates physiological and psychological adaptations that enable athletes to better tolerate exercise stress. Given that prolonged endurance training is generally associated with at least mild dehydration (1-3%), it is conceivable that aerobically-trained people may also be better adapted to tolerate hypohydration. Therefore, the purpose of this study was to examine the hypothesis that aerobic fitness attenuates mild hypohydration-augmented physiological strain and associated performance decrement in a temperate environment.

Methods. *Participants* were six untrained and six trained, non-heat acclimated males of similar age (31 ± 9 *vs.* 25 ± 6 y). Trained participants had higher training frequency (6.0 ± 1.3 *vs.* 1.0 ± 0.8 d•wk^{-1}) and VO_{2peak} (64 ± 8 *vs.* 45 ± 4 ml•kg^{-1}•min^{-1}), but lower body mass (71.8 ± 4.3 *vs.* 78.6 ± 9.7 kg) and adiposity (8 ± 2 *vs.* 16 ± 5% body fat) than Untrained. The study was approved by the University of Otago Human Ethics Committee, and participants provided their informed consent. *Procedure:* After two full familiarisations participants completed two 80-min exercise trials (24.3 ± 0.6 °C, 50% rh, air velocity: 4.5 m•s^{-1}), 1-3 wk apart, in balanced order. Trials comprised of 40-min constant load cycling (70%VO_{2peak}) before a 40-min self-paced performance ride, on an electromagnetically-braked ergometer. On the evening preceding each trial participants undertook 50 min of exercise plus heat stress followed by complete (EUH) or partial (resulting in a 1.5-2% reduction in body mass; HYPO) overnight rehydration. During EUH, 100% of metabolism-corrected mass loss was replaced at 10-min intervals throughout exercise by ingestion of a solution containing NaCl (2.9 g•L^{-1}) and artificial sweetener, whist during HYPO only 20% was replaced during constant load exercise followed by *ad libitum* intake during the performance ride. *Measures:* Substrate oxidation and the 70% work rate were calculated from respiratory gas analysis (15-min intervals) throughout familiarisation and experimental trials. Nude body mass and urine specific gravity (U_{SG}) were measured before and after all sessions. Rectal temperature, heart rate and local sweat rates were recorded throughout trials. Blood volume changes and plasma osmolality were estimated from venous samples drawn at rest, 10, 40 and 80 min. *Analyses:* The inferential analyses were unpaired t-test, and one- to three-way ANOVAs ($\alpha = 0.05$) due to one between-subjects factor (Fitness) and two within-subjects factors (Hydration, Time). Post hoc *t*-tests were Bonferroni corrected.

Results. *Rest*: At baseline in EUH, both fitness groups had comparable change in body mass (*cf.* baselines: Untrained +0.2 ± 0.3, Trained +0.5 ± 0.8%, respectively [mean ± SE]; $p = 0.43$) and plasma osmolality (276 ± 1 *vs.* 278 ± 1 mosmol•kg^{-1}, $p = 0.11$) but Untrained had higher U_{SG} (1.016 ± 0.002 *vs.* 1.009 ± 0.002 g.cm^{-3}; $p = 0.04$). At Baseline in HYPO, both groups had similar ($P > 0.4$) reductions in body mass (both -1.8 ± 0.1%), blood volume (both 3 ± 1%) and raised U_{SG} (1.030 ± 0.002 *vs.* 1.030 ± 0.001) and plasma osmolality (282 ± 1 *vs* 283 ± 2 mosmol•kg^{-1}), all of which differed from EUH ($p < 0.05$). *Exercise:* Heart rate and heart rate drift in constant-load exercise were increased during HYPO compared with EUH for Untrained (71 ± 2 *vs.* 63 ± 3% of heart rate range; $p = 0.02$, and 0.55 ± 0.08 *vs.* 0.41 ± 0.07 beats•min^{-2}; $p = .001$) but not Trained (71 ± 2 *vs.* 70 ± 2%; $p = 0.20$, and 0.23 ± 0.02 *vs.* 0.22 ± 0.02 beats•min^{-2}; $p = 0.24$). Rectal temperature was higher in HYPO compared to EUH during both 40-min phases, but the increase was significant only for Untrained (37.60 ± 0.14 *vs.* 37.34 ± 0.10ºC; $p = 0.02$). Similarly, HYPO effect on rate of T_c rise during constant-load phase was fitness dependent (hydration*fitness, $p = 0.001$); being significant for Untrained (29 ± 4%; $p = 0.001$) but not Trained (4 ± 5%; $p = 0.17$). Untrained but not Trained showed lower whole-body sweat rate and higher forehead sweat threshold in HYPO compared with EUH, but both groups had lower sweating sensitivity and whole-body sweat rate *vs.* plasma osmolality in HYPO than in EUH. Performance trial distance (D) and mean power output (PO) were reduced ($p < 0.05$) during HYPO compared to EUH, with Trained (D = -3 ± 3%; PO = -7 ± 3%) tending ($p = 0.13$) to be less affected than Untrained (D = -7 ± 1%; PO = -13 ± 7%).

Conclusion. Moderate hypohydration of 1.5-2% body mass augments thermal (T_c) and cardiovascular (HR) strain and impairs endurance performance in a temperate environment, but aerobic fitness attenuates some of these effects.