Proceedings of the AIAA Life Sciences and Space Medicine Conference, Houston, TX, April 3-5, 1995. p. 95-96. Abstract.

HYPERVOLEMIA FROM DRINKING HYPERHYDRATION SOLUTIONS AT REST AND EXERCISE

John E. Greenleaf, Ph.D., Robin Looft-Wilson, M.S., NASA Ames Research Center, Moffett Field, CA 94035; Catherine G.R. Jackson, Ph.D., Univ. No. Colorado; Ghislaine Geelen, Ph.D., Univ. Claude Bernard; Paul R. Barnes, Ph.D., San Francisco State Univ.; Christopher D. Jensen, M.S., and James H. Whittam, Ph.D., Shaklee U.S., Inc.

The mechanism of muscular fatigue from physical work and exercise (high metabolism) is not clear, but involves disturbances of muscle surface membrane excitation-contraction coupling from changes in sarcoplasmic reticulum Ca^{2+} release, cell H^+ and Pi responses, and carbohydrate metabolism. Fatigue in people at rest (low metabolism) involves both psychological and physiological factors, probably in different proportions. One common factor appears to be the level and distribution of water and electrolytes within muscle cells and other vascular, interstitial, body fluid compartments. The vascular fluid volume, composed of plasma and red blood cells, is a primary regulatory factor for cardiovascular function; reduction of vascular volume (hypovolemia) and total body water (hypohydration) adversely affect exercise performance. Plasma volume and plasma ionic-osmotic constituent concentrations are also regulatory factors for body thermoregulation, which is often compromised from exercise-induced hypovolemia and hypohydration.

Rehydration of dehydrated people on earth is relatively easy with appropriate food (osmols), fluid, and a restful environment. But ad libitum drinking under stressful conditions; e.g., heat, exercise, or prior dehydration, results in involuntary dehydration defined as the delay in full fluid replacement (euhydration) during and following loss of body fluid. Astronauts, with their reduced total body water are euhydrated while in weightlessness, but become "dehydrated" during reentry and landing. Thus, people subjected to acute or chronic stress are probably somewhat "dehydrated" as well as fatigued.

Many rehydration drinks are more concentrated (hypertonic-hyperosmotic) with respect to the normal plasma osmolality of 285 mOsm/kg H_2O and more of the drink osmols are contributed by carbohydrates than by ionized substances. There have been few studies on the efficacy of various drink formulations for increasing body fluid compartment volumes, especially plasma volume, in rested hydrated subjects. Recent findings from our laboratory have indicated that drinks containing greater concentrations of ionized substances (Performance 1 and AstroAde) up to 157 mEq/L Na^+ induced greater levels of hypervolemia in resting, moderately dehydrated men, and were also better than water for attenuating the characteristic hypovolemia during supine, submaximal, leg ergometer exercise.

To test the hypothesis that drink composition is more important than drink osmolality (Osm) for maintaining and increasing plasma volume (PV) at rest and exercise, 6 men (22-39 yr) underwent six treatments while sitting for 90 min ($\dot{V}O_2 = 0.39$ L/min) followed by 70 min upright ergometer exercise ($\dot{V}O_2 =$ 2.08 ± 0.33 L/min, 70% ± 7% $\dot{V}O_2$ peak). Resting, intermittent drink formulations were: P1 (20 mEq Na^+, 365 mOsm/kg H_2O), P2 (40 mEq Na^+, 791 mOsm/kg H_2O), P2G (40 mEq Na^+, 80 mL glycerol, 1,382 mOsm/kg H_2O), AA (157 mEq Na^+, 253 mOsm/kg H_2O), and 01 and 02 (no drinking). The exercise drink (10 mL/kg, 768 mL) was P1 for all treatments, except 02. Rest %ΔPV increased by 4.7% with P1 and 7.9% with AA. Percent Δ in PV during exercise was +1% to +3% with AA, -6% to 0% with P1, P2, P2G, and 01, and -8% to -5% with 02. AstroAde (AA, 157 mEq Na^+) with the lowest osmolality (253 mOsm/kg H_2O) maintained PV at rest and exercise, while the other drinks with low Na^+ and higher osmolality (365 to 1,382 mOsm/kg) did not. But Performance 1 also increased PV at rest. Thus, drink composition may be more important than drink osmolality for increasing plasma volume at rest and for maintaining it during exercise.