

# Hypervolemia in Men from Drinking Hyperhydration Fluids at Rest and During Exercise

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## Summary

To test the hypothesis that drink composition is more important than drink osmolality (Osm) for maintaining and increasing plasma volume (PV) at rest and during exercise, six men (22–39 yr,  $76.84 \pm 16.19$  kg,  $2.99 \pm 0.45$  L/min  $\dot{V}O_2$  peak) each underwent six treatments while sitting for 90 min ( $\dot{V}O_2 = 0.39$  L/min) and then performed upright ergometer exercise for 70 min ( $\dot{V}O_2 = 2.08 \pm 0.33$  l/min,  $70\% \pm 7\%$   $\dot{V}O_2$  peak). Drink formulations (10 ml/kg body weight,  $\bar{X} = 768$  ml) for the sitting period were: P1 (55 mEq Na<sup>+</sup>, 365 mOsm/kg H<sub>2</sub>O), P2 (97.1 mEq Na<sup>+</sup>, 791 mOsm/kg), P2G (113 mEq Na<sup>+</sup>, 80 ml glycerol, 1,382 mOsm/kg), HyperAde (HA) (164 mEq Na<sup>+</sup>, 253 mOsm/kg), and O1 and O2 (no drinking). The exercise drink (10 ml/kg, 768 ml) was P1 for all treatments except O2. Plasma volume at rest increased ( $p < 0.05$ ) by 4.7% with P1 and by 7.9% with HA. Percent change in PV during exercise was +1% to +3% (NS) with HA; -6% to 0% (NS) with P1, P2, P2G, and O1; and -8% to -5% ( $p < 0.05$ ) with O2. HyperAde, with the lowest osmolality (253 mOsm/kg), maintained PV at rest and during exercise, whereas the other drinks with lower Na<sup>+</sup> 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.

## Introduction

The mechanism of muscular fatigue caused by physical work and exercise (high metabolism) is not clear, but it involves disturbance of muscle surface membrane excitation-contraction coupling as a result of changes in sarcoplasmic reticulum Ca<sup>2+</sup> release, cell H<sup>+</sup> and inorganic P responses, and carbohydrate metabolism (Fitts 1994). Low-metabolism fatigue in people at rest involves both psychological and physiological factors (Bartlett 1953, Booth 1991), probably in various proportions. One common factor appears to be the concentration and distri-

bution of water and electrolytes within muscle cells and other body fluid compartments (vascular, interstitial, and cellular). The vascular fluid volume, composed of plasma and red blood cells, is a primary regulator of cardiovascular function; reduction of this volume (hypovolemia) and total body water (hypohydration) adversely affects exercise performance (Greenleaf 1973). In addition, plasma volume and ionic-osmotic constituent concentration of plasma and cells are also regulatory factors for body thermoregulation, which is often compromised with exercise-induced hypovolemia and hypohydration (Greenleaf and Castle 1971, Greenleaf 1979, Kozlowski et al. 1980).

Rehydration of dehydrated people is relatively easy with appropriate food (osmols), fluid, and a restful environment. But ad libitum fluid intake under stressful conditions, e.g., heat, exercise, or prior dehydration, results in involuntary dehydration (Greenleaf 1991, 1992; Rothstein et al. 1947) defined as the delay in full fluid replacement (euhydration) during and following loss of body fluid. Stress caused by doing mental arithmetic can also cause hypovolemia (S. Patterson, personal communication). Thus, people subjected to acute or chronic stress may be somewhat "dehydrated" as well as fatigued.

Research on body fluid distribution and rehydration fluid composition, stimulated by demands on troops during World War II (Adolph 1947, Pitts et al. 1944), has continued with increasing intensity for military personnel (Marriott 1994) with application for recreational exercisers and competitive athletes (Murray 1987). Many current rehydration formulations are more concentrated (hypertonic-hyperosmotic) than the normal plasma osmolality (285 mOsm/kg H<sub>2</sub>O) with more of the drink osmols contributed by carbohydrate than by ionized solute (Murray 1987). Optimal fluid composition for rapid gastric emptying and transfer through the gastrointestinal system appears to be 20–30 mEq/L sodium, 5–10 mEq/L potassium (with chloride as the only anion), and 0.9%–10% carbohydrate, preferably glucose (Gisolfi 1991). Measurement of gastric and gastrointestinal emptying of fluid does not necessarily reflect change in plasma or interstitial fluid volumes. There have been few

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studies on the efficacy of various drink formulations for increasing body fluid compartment volumes, especially plasma volume (PV) in rested hydrated subjects (Luetkemeier and Thomas 1994; Maughan and Noakes 1991, Murray 1987).

Recent findings in our laboratory indicated that fluid formulations containing greater concentration of ionized solute (Performance 1 and HyperAde) up to 164 mEq/L  $\text{Na}^+$  induce significantly ( $p < 0.05$ ) greater levels of hypervolemia in resting, moderately dehydrated men, and are also better than water for attenuating the hypovolemia during supine, submaximal, leg ergometer exercise (Greenleaf et al. 1992). The present study was designed from these preliminary findings to determine the effect of intermittent ingestion of two previously tested and two newly formulated hypertonic solutions containing various osmotic and carbohydrate concentrations on plasma volume during rest followed by upright submaximal ergometer exercise. To test the physiological effect of the hyperhydration, thermoregulatory parameters were measured.

The authors thank the subjects for their dedication and cooperation. This study was supported by Shaklee Grant JSRA-7 and NASA Grants 199-18-12-07 and NAG8-227.

## Methods

### Subjects

Six men, aged 22–39 yr, (table 1) gave written informed consent for this study which was approved by the Ames Research Center Human Research Experiments Review Board and the San Francisco State University Human Subjects' Committee. The men passed a comprehensive medical examination which included their medical history, urine and blood analyses, and a treadmill exercise test. All were nonsmokers and none took nonprescribed drugs.

### Procedure

Six treatments for each subject were conducted semi-randomly at weekly intervals. The experimental protocol consisted of intermittent drinking during 90 min of sitting rest, 15 min to move to the cycle ergometer and to readjust sensors, intermittent drinking during 70 min of upright submaximal ( $70\% \pm \text{SD } 7\%$  of peak oxygen uptake) leg exercise, followed by 10 min of sitting recovery (fig. 1).

The subjects arrived at the Laboratory for Human Environmental Physiology at 0700 hr and ate a standardized

carbohydrate breakfast: 220 ml of reconstituted frozen orange juice and two toasted English muffins with jelly. After breakfast they urinated and inserted a rectal thermometer 16 cm. Dressed in shorts (weighed dry), they were weighed ( $\pm 5$  g) on a digital scale (model 5780, National Controls, Inc., San Carlos, California). The men then sat in a chair for 90 min while skin probes and sensors (EKG, laser-Doppler, temperature, and sweat capsules) were attached and a forearm venous catheter (Quik-Cath, Travenol Laboratories, Inc., Deerfield, Illinois) was inserted. Body weight was measured and additional urine samples were collected after the rest and exercise periods (fig. 1).

### Drinks and Drinking

Each subject drank one of four fluid formulations (table 2), divided into seven portions, during the rest and exercise periods (fig. 1). The drinks were designated P1 (Performance 1), P2 ( $2 \times$  Performance 1 concentration), P2G (P2 + 80 ml glycerol), HA (HyperAde), or 0 (no drinking). Performance 1 is a commercial product of Shaklee U.S., Inc., San Francisco, California; HyperAde was also packaged by Shaklee. All drinks, in powder form, were mixed just prior to testing. The high salt content of HA, as well as the very sweet taste of P2G, were apparent to the subjects. Drink volume was 10 ml/kg body weight for both resting and exercise phases (table 3). Glycerol was used for its water retaining properties. Performance 1 was consumed during exercise with five treatments, and no drinking was done during the sixth. Thus, for the six treatments, drink designations for rest/exercise, respectively, were: P1/P1, P2/P1, P2G/P1, HA/P1, 0/P1, and 0/0.

### Physiological Measurements

After three familiarization sessions, the peak oxygen uptake ( $\dot{V}\text{O}_2$  peak, table 1) was measured with the subjects in the upright sitting position on a model 846 cycle ergometer (Quinton Instruments Co., Seattle, Washington). The respiratory measurement system utilized a low-resistance, low-dead-space Rudolph Valve (model 2700, Hans Rudolph, Inc., Kansas City, Missouri), a Tissot-tank calibrated electronic spirometer (model S-301 Pneumoscan, K.L. Engineering Co., Sylmar, California), and a 3-L mixing chamber from which expired gas was sampled at 0.5 L/min, drawn through and dried by anhydrous calcium sulfate (N.A. Hammond Drierite Co., Xenia, Ohio) and routed to oxygen and carbon dioxide analyzers (Applied Electrochemistry models S-3AI and CD-3A, respectively; Ametek, Thermox Instruments Division, Pittsburgh, Pennsylvania). The analyzers were calibrated with standardized gases (Lloyd-Haldane apparatus).

Analog data were processed on-line with an analog-to-digital converter (VISTA system IBM model 17002, Vacumed, Ventura, California) and transmitted to an IBM (model AT) computer; output metabolic data were printed each 15 sec. Peak data were the mean of the final four 15-sec values. The submaximal exercise load corresponded to an oxygen uptake of  $70\% \pm SD 7\%$  of the measured  $\dot{V}O_2$  peak (table 4).

Skin blood velocity was measured on the left temple and left anterior-medial thigh with a laser-Doppler system (model BPM 403A, LaserFlo Blood Perfusion Monitor, TSI Inc., St. Paul, Minnesota). Heart rate was determined with a cardiometer (model 78203C, Hewlett-Packard, Waltham, Massachusetts) via three skin electrodes (Silvon No. 01-3630 Ag/AgCl, NDM, Dayton, Ohio), two located on the anterior shoulders and the third over the fifth intercostal space.

Local sweat rate was measured via capsules (Spaul 1983) on the left arm, forearm, and anterior thigh with resistance hygrometry sensors (model 2300 H1T21, Thunder Scientific Corp., Albuquerque, New Mexico); room air was the reference. The sweat capsules were located adjacent to skin-temperature thermistors. The sensors were calibrated with solutions of standard humidity: 33% with  $MgCl_2$ , 52% with  $MgNO_3$ , and 96.5% with  $K_2SO_4$ , and room air (43.5%) was measured with a psychrometer. Regression equations for measured versus actual humidities were: thigh ( $Y = 1.10 X - 0.78$ ,  $r = 0.99$ ), forearm ( $Y = 1.03 X - 4.97$ ,  $r = 0.98$ ), and arm ( $Y = 1.15 X - 13.40$ ,  $r = 0.99$ ). Sensor and room air relative humidities were recorded with a DigiTech Datalogger (model 1100, United Systems Corp., Dayton, Ohio). Sweat rate ( $M_{sw}$ ) at the three sites was calculated as follows:  $M_{sw} = [\dot{V}_a(W_{out} - W_{in})]/[(A_{sw})(SVA)]$  where  $M_{sw}$  = sweat rate ( $g \cdot cm^{-2} \cdot hr^{-1}$ ),  $\dot{V}_a$  = volume flow rate ( $L/min$ ),  $W_{out}$  = absolute humidity ratio leaving capsule ( $lb H_2O/lb$  dry air),  $W_{in}$  = absolute humidity ratio of control ( $lb H_2O/lb$  dry air),  $A_{sw}$  = area of collection capsule ( $3.14 cm^2$ ), and  $SVA$  = specific volume of air ( $L/g$  dry air).

Body water balance (gross sweat rate) was calculated:  $balance = (weight\ loss - blood + urine\ loss + drink\ volume) - (CO_2\ out - O_2\ in)$ .

Rectal and skin temperatures were measured with series 400 thermistors (Yellow Springs Instrument Co., Yellow Springs, Ohio). Skin thermistors, attached with holders that permitted free movement of air (Greenleaf and Williams 1976), were located at six sites: arm, forearm, thigh, calf, chest, and back. A Squirrel meter/logger (Grant model 1200, Science/Electronics Inc., Miamisburg, Ohio) was used for processing sensor signals. Mean skin temperature ( $\bar{T}_{sk}$ ) (Greenleaf and Castle 1972, Hardy

and Dubois 1938) was calculated:  $\bar{T}_{sk} = 0.06 (T_{arm}) + 0.13 (T_{forearm}) + 0.21 (T_{thigh}) + 0.21 (T_{calf}) + 0.19 (T_{chest}) + 0.20 (T_{back})$ . Mean room dry-bulb temperature was  $21.8^\circ C \pm SD 0.3^\circ C$ , and relative humidity was  $50\% \pm 2\%$  (table 5). A fan increased airflow over the subject during rest ( $23 \pm SD 4$  ft/min) and exercise ( $53 \pm 4$  ft/min).

### Blood Measurements

Blood samples (15 ml each (20 ml each at -25 and -35 min), 115 ml/experiment) were withdrawn through an 18-gauge catheter (Quik-Cath, Baxter Healthcare Corp., Deerfield, Illinois) inserted into the right antecubital vein. Blood samples were divided in four Vacutainer<sup>R</sup> tubes: tube 1 = 2 ml for hemoglobin (Hb) and hematocrit (Hct); tube 2 = 3 ml for glucose; tube 3 = 10 ml for sodium, potassium, osmolality, RBC, WBC, platelets, and glycerol; and tube 4 = 5 ml for Evans blue (plasma volume) analysis. Hemoglobin and Hct were measured immediately (manually). Hemoglobin was measured (cyanomethemoglobin method) with the Coulter Diluter II and Hemoglobinometer (Coulter Electronics, Hialeah, Florida). Blood for Hct was drawn into four capillary tubes, centrifuged for 10 min at 11,500 rpm (centrifuge model MB, International Equipment Co., Needham Heights, Massachusetts) and read with a modified microcapillary tube reader (model CR, International Equipment Co.). Hemoglobin and Hct were also calculated automatically with a Coulter model STKS analyzer. Plasma was frozen ( $-20^\circ C$ ) for subsequent analysis.

Plasma sodium, potassium, glucose, citrate, and glycerol concentrations were measured with a Cobas Mira S analyzer (Roche Diagnostic Systems, Inc., Branchburg, New Jersey): sodium (glass membrane) and potassium (PVC valinomycin membrane) with ion-selective electrodes; glucose with hexokinase-NAD reactions and NADH read at 340 nm; glycerol with glycerolkinase-glycerophosphate oxidase-peroxidase reactions with the quinoneimine complex read at 490-550 nm; and citrate with citrate lyase for NADH to  $NAD^+$  at 340 nm. Plasma osmolality was measured by freezing-point depression (model 3DII, Advanced Instruments Digimatic Osmometer, Needham Heights, Massachusetts).

Plasma volume was measured on frozen plasma with the Evans blue dye (T-1824, New World Trading Corp., DeBary, Florida) dilution technique from one 10-min post-dye-injection blood sample (Campbell et al. 1958, Greenleaf et al. 1979). Freezing does not change T-1824 concentration over time. Plasma was eluted through machine-packed chromatographic columns (model PD-10, Sephadex G-25M, Pharmacia LKB, Uppsala, Sweden) and the elutriate was read at 615 m $\mu$ . Plasma volume was

calculated:  $PV = (V \cdot D \cdot St \cdot v) / (T \cdot 1.03)$  where  $V$  = volume T-1824 injected,  $D$  = dilution of standard,  $St$  = standard absorbance,  $v$  = volume of sample extracted,  $T$  = test sample absorbance (subtract plasma blank), and  $1.03$  = correction factor for slow dye uptake by tissues. Percent change in plasma volume was calculated using the Hb-Hct transformation equation (Greenleaf et al. 1979).

Data from the new Sephadex column were compared with data from the standard manually packed column (Greenleaf 1979b). The optical density of 0.2 ml T-1824/10 ml acetone standard was measured (0.130); then 0.2 ml T-1824 was mixed with Teepol-phosphate and eluted through nine manually packed chromatographic columns and nine Sephadex columns. Mean ( $\pm$ SD and  $\pm$ SE) optical density for the manual and Sephadex columns was 0.1103 ( $\pm$ 0.0041 and  $\pm$ 0.0014) and 0.0949 ( $\pm$ 0.0026 and  $\pm$ 0.0008), respectively ( $\Delta \bar{X} = 14.0\%$ ,  $p < 0.0001$ ). Thus, optical density from the Sephadex column was lower and variability of the elutriate was about half that of the manually packed column.

Mean corpuscular volume ( $MCV, \mu^3$ ) =  $10 (\text{Hct} \cdot 0.96) / (\text{RBC in } 10^6/\text{mm}^3)$ .

Hematocrit and hemoglobin concentration were determined manually (as indicated above) and with calculated values from the Coulter counter (fig. 2). The calculated Hb values were lower and the Hct values were higher than their respective manual values which were used for the plasma and blood volume determinations.

### Urine Measurements

The volume of urine, collected at the end of rest ( $-15$  min) and after exercise ( $+10$  min of recovery), was timed and measured in a graduated cylinder. Urinary excretion rate ( $\dot{V}$ ) was expressed in mL/min. Urinary sodium ( $U_{Na}$ ), potassium ( $U_K$ ), and osmotic ( $U_{osm}$ ) concentrations were determined by the same methods used for the respective plasma variables. Other urine functions were calculated: osmotic clearance ( $C_{osm}$ ) was urine osmotic excretion ( $U_{osm} \dot{V}$ ) divided by plasma osmolality ( $P_{osm}$ ) averaged over the urine collection period; free water clearance ( $C_{H_2O}$ ) was  $\dot{V} - C_{osm}$ ; and fractional ionic excretion was  $U_{Na} \dot{V}$  and  $U_K \dot{V}$ .

### Statistical Analysis

The data were analyzed, as a first approximation, by Student's  $t$ -test for dependent variables. The null hypothesis was rejected when  $p < 0.05$ . Nonsignificant differences were denoted by NS or trend or tendency.

## Results and Discussion

### Blood Data

**Plasma and mean corpuscular volume**—Percent change in plasma volume from  $-105$  min (upper panel), and from  $-105$  min (rest) and from 0 min (exercise) (lower panel), are presented in figure 3. At the end of the rest phase ( $-15$  min) the greater ( $p < 0.05$ ) increase in PV occurred with the HAP1 (by 7.9%) and P1P1 (by 4.7%) treatments; the lesser increase was with the 00 (by 1.7%) and OP1 (by 1.0%) treatments. Change from sitting upright in a chair with the thighs horizontal, to sitting upright on the cycle with thighs positioned at a more downward angle (position change) resulted in decreasing trends in PV at time zero with all treatments which resulted from the increased hydrostatic pressure in the lower extremities. Percent change in PV with OP1 at time zero was similar to that of 00, so the two no-drinking treatments responded similarly. During exercise, HAP1 maintained the highest PV, followed by P1P1, OP1, P2GP1, P2P1, and 00 in decreasing order (fig. 3, upper panel). Thus, drinking P1 during exercise by dehydrated subjects can increase PV to the hydrated-control level. Reduction in PV by 4% to 9% occurred with all treatments at 10 min of exercise, with essentially similar rates of recovery regardless of whether or not fluid was consumed (fig. 3, lower panel). The 00 response was similar to the P2GP1 response. Thus, the rate of PV restitution during exercise appeared to be independent not only of drink composition, but also of whether or not fluid was consumed.

Mean corpuscular volumes (fig. 4) were not different from each other or over time during rest or exercise, indicating that there was no appreciable exchange of vascular fluid into or from red blood cells.

**Osmolality**—Plasma osmotic concentration was within the upper half of the normal range (277–297 mOsm/kg  $H_2O$ ) and varied between 288 and 293 mOsm/kg  $H_2O$  in the rest phase (fig. 5, upper panel). In both nondrinking treatments (OP1 and 00), plasma osmolality remained constant during the first hour of rest. Osmolality varied by  $\pm 2$  mOsm/kg by the end of rest; P1P1 and P2GP1 exhibited positive changes and HAP2 and OP1 exhibited negative changes (fig. 5, middle panel). All osmotic responses were within the normal variability. Plasma osmolality increased during exercise with all treatments, especially OP1 (with drinking P1) and 00 (with no drinking). Intake of P1 had no apparent effect on change in osmolality. Drinks P2GP1 and HAP1 had the lower osmotic concentration at the end of exercise (fig. 5, upper panel) which accompanied the greater increase in plasma volume. As expected, treatment 00 exhibited the greatest increase in

osmolality by the end of exercise; HAP1 had the least increase (fig. 5, middle panel). Also, HAP1, with the highest ionic osmolality, had the greatest increase in plasma osmotic content; osmotic content of the remaining treatments returned to normal by the end of exercise (fig. 5, lower panel). The acute decrease in plasma osmotic content at the beginning of exercise accompanied, and possibly induced, the shift of plasma from the vascular space.

**Sodium**— Plasma sodium concentration generally followed comparable osmotic concentration, especially when respective percent change in content was compared (figs. 5 and 6, lower panels). Because sodium and accompanying anions account for a large part of plasma osmolality (plasma sodium and osmotic concentrations  $r = 0.93$ ), the osmotic contribution of carbohydrates was minimal.

**Potassium**— Plasma potassium was within the normal range at rest (fig. 7, upper panel) and, unlike sodium, both potassium concentration and content exhibited immediate increase with the onset of exercise (fig. 7, lower panel). The potassium content in the drinks did not appear to influence the concentration or content responses at rest or during exercise. At 70 min of exercise the greater percent change in content occurred in HAP1, OP1, and P2P1 (containing potassium), and the smallest change occurred in P1P1 (also containing potassium), with 00 (containing no potassium) in the middle (fig. 7, lower panel). Thus potassium, the major intracellular ion, did not accompany the shift of sodium and water from the vascular space at the beginning of exercise.

**Glucose**— Plasma glucose was elevated above the normal range of 64–115 mg/dL at the beginning of the rest period, probably a result of the high-carbohydrate breakfast (fig. 8, upper panel). Glucose concentration decreased with all treatments during rest and position change, with a greater decrease for those with no carbohydrate (HAP1, 00, OP1). With the exception of HAP1, glucose concentration and content decreased immediately with the onset of exercise (similar to osmolality and sodium), and then increased as exercise continued (fig. 8, lower panel). Glucose concentration for treatments OP1 and 00 were similar at time zero, but by the end of exercise that of OP1 increased the most (to 110 mg/dL) and that of 00 increased the least (to 85 mg/dL) by 70 min (fig. 8, upper panel). Similar results were evident with changes in glucose concentration and content. Thus, consumption of glucose during exercise increased both plasma glucose concentration and content.

**Glycerol**— Only one drink (P2G) contained appreciable (80 mL) glycerol. Plasma glycerol increased to  $168 \pm 33$  mg/dL at zero min of rest, remained at that level

during the first 30 min of exercise, and then decreased to  $116 \pm 18$  mg/dL at 70 min (fig. 9, upper and lower panels). Apparently there was some glycerol metabolism: the change in glycerol content decreased from  $3,462\% \pm 1,430\%$  at zero min to  $2,208\% \pm 768\%$  at 70 min of moderately heavy ergometer exercise.

**Citrate**— Mean resting plasma citrate varied from  $1.7 \pm 0.2$  to  $2.2 \pm 0.3$  mg/dL, within the normal range of 1.7–3.0 mg/dL (fig. 10, upper panel; appendix 2). Citrate was present in all drinks: 3.87 g/2 L in P1, 7.74 g/2 L in P2 and P2G, and 15.44 g/2 L in HA (table 2). Plasma citrate increased by 0.5 pg/mL (P2G) to 1.7 pg/mL (HA), and remained essentially constant with OP1 and 00 at zero min (fig. 10, lower panel). In spite of the fact that drink P1 was consumed during exercise with all treatments except 00, citrate concentration in the four rest citrated drinks converged at about 0.75 mg/dL at rest, with a pronounced decrease in citrate with HA as consumption changed from 15.44 g/2 L at rest to 3.87 g/2 L during exercise. Reducing citrate consumption by 50% from rest to exercise did not appreciably alter the change in citrate content in the P1P1, P2P1, and P2GP1 treatments (fig. 10, lower panel).

## Urine Data

**Excretion rate and electrolyte-osmotic concentration**— Urine excretion rate ( $\dot{V}$ ) at rest varied from  $1.2 \pm 0.3$  mL/min (OP1) to  $3.2 \pm 1.2$  mL/min (P2GP1), with a mean level ( $N = 6$ ) of  $2.3 \pm 0.3$  mL/min (fig. 11, solid line). Normal resting  $\dot{V}$  is 1.0 mL/min. Excretion rate during exercise varied from  $0.8 \pm 0.3$  mL/min (OP1 and 00) to  $3.2 \pm 0.8$  mL/min (HAP1), with a mean rate ( $N = 6$ ) of  $1.8 \pm 0.4$  mL/min (fig. 11, dashed line) which was not significantly lower than the rest mean rate. Exercise  $\dot{V}$  was depressed similarly with P2P1, OP1, and 00, but not with P2GP1 or HAP1 with their higher osmotic concentrations.

In general, urine sodium, potassium, and osmotic concentrations were lower with P1P1 and P2P1, and higher with HAP1, OP1, and 00 treatments (table 6). The former reflected the lower drink osmolality, while the latter resulted from the greater ionic content of HAP1 (in spite of its lower osmolality); the urine response to dehydration was similar to that following high salt consumption. The somewhat elevated urine potassium concentration during exercise over that at rest resulted from increased muscle activity.

**Sodium excretion**— Mean ( $\pm$ SE) sodium excretion for the six treatments was  $168 \pm 19$   $\mu$ Eq/min ( $p < 0.05$ ) during exercise (–15 to +10 min) (fig. 12, upper panel). The large increase in  $U_{Na} \cdot \dot{V}$  during rest and exercise with

HAP1 was due to its high sodium concentration (164 mEq/L).

**Potassium excretion**— There was no significant difference between mean  $U_K \cdot \dot{V}$  at rest ( $58 \pm 8 \mu\text{Eq}/\text{min}$ ) and during exercise of  $75 \pm 20 \mu\text{Eq}/\text{min}$  (fig. 12, lower panel). The large increase in potassium excretion with HAP1 during exercise probably accompanied the fluid shift from muscle cells to the interstitial and vascular spaces.

**Osmotic clearance**— There was no significant difference between mean  $U_{\text{Osm}} \cdot \dot{V}/P_{\text{Osm}}$  at rest ( $3.0 \pm 0.2 \text{ mL}/\text{min}$ ) and during exercise ( $2.4 \pm 0.4 \text{ mL}/\text{min}$ ) (fig. 13, upper panel). The somewhat increased osmotic clearance with HAP1 during exercise reflected the increased concomitant excretion of sodium and potassium.

**Free water clearance**— There was no significant difference between mean free water clearance ( $C_{\text{H}_2\text{O}}$ ) at rest ( $-0.74 \pm 0.23 \text{ mL}/\text{min}$ ) and during exercise ( $-0.60 \pm 0.24 \text{ mL}/\text{min}$ ) (fig. 13, lower panel). Treatments with higher ionic content (HAP1) and dehydration (OP1 and 00) have the least  $C_{\text{H}_2\text{O}}$ , suggesting greater water retention.

### Physiological Data

**Heart rate**— Mean heart rate varied from  $71 \pm 6$  to  $87 \pm 8$  beats/min during the rest phase to  $149 \pm 9$  to  $160 \pm 8$  beats/min at 70 min of exercise (fig. 14, upper panel). The increase in heart rate during exercise was lowest ( $61 \pm 10$  beats/min) with P1P1, and greatest ( $74 \pm 10$  beats/min) with HAP1 (fig. 14, lower panel). Dehydration (00) did not result in the characteristic elevated heart rate at rest or during exercise.

**Rectal and mean skin temperatures**— Mean ( $\pm$ SE) rectal temperature ( $T_{\text{re}}$ ) was stable with each treatment at rest; it varied from  $36.6 \pm 0.2^\circ\text{C}$  with P2GP1 to  $37.2 \pm 0.1^\circ\text{C}$  with OP1 (fig. 15, upper panel). The range and variability of  $T_{\text{re}}$  decreased by time zero. Equilibrium levels of  $T_{\text{re}}$  at min 70 of exercise varied from  $37.98 \pm 0.10^\circ\text{C}$  with P1P1 to  $38.29 \pm 0.17^\circ\text{C}$  with OP1. Mean change in  $T_{\text{re}}$  during exercise (fig. 15, lower panel) did not exhibit the expected response where the OP1 and 00 changes in  $T_{\text{re}}$  should have been the greatest. In fact, P2GP1 showed the greatest increase ( $1.41 \pm 0.13^\circ\text{C}$ ); followed by P2P1 ( $1.34 \pm 0.17^\circ\text{C}$ ), 00 ( $1.33 \pm 0.14^\circ\text{C}$ ), HAP1 ( $1.31 \pm 0.14^\circ\text{C}$ ), OP1 ( $1.25 \pm 0.15^\circ\text{C}$ ), and P1P1 ( $1.14 \pm 0.08^\circ\text{C}$ ). Thus it appears that glycerol ingestion tends to elevate  $T_{\text{re}}$  whereas P1 tends to attenuate the increase in  $T_{\text{re}}$ .

Absolute average mean skin temperatures ( $\bar{T}_{\text{sk}}$ ) (fig. 16, upper panel) and the change in  $\bar{T}_{\text{sk}}$  (fig. 16, lower panel) were not significantly different between the six treat-

ments. Treatment 00  $\bar{T}_{\text{sk}}$  was nearest zero, while treatment OP1 tended to have the greater decrease (fig. 16, lower panel). Lower  $\bar{T}_{\text{sk}}$  suggests greater sweating and evaporative heat loss.

**Forearm and thigh sweat rates**— Mean ( $\pm$ SE) rest (time zero) forearm sweat rate varied from  $0.02 \pm 0.02 \text{ mg}/\text{min} \cdot \text{cm}^2$  (OP1) to  $0.16 \pm 0.09 \text{ mg}/\text{min} \cdot \text{cm}^2$  with P2GP1 (fig. 17, upper panel). Sweat rate was unchanged for the first 10 min of exercise, when all rates began to rise to reach  $0.22 \pm 0.09 \text{ mg}/\text{min} \cdot \text{cm}^2$  (00) to  $0.49 \pm 0.11 \text{ mg}/\text{min} \cdot \text{cm}^2$  (OP1). Change in forearm sweat rate responded similarly where 00 increased least (as expected) by  $0.17 \pm 0.07 \text{ mg}/\text{min} \cdot \text{cm}^2$ ; and OP1 increased most by  $0.47 \pm 0.10 \text{ mg}/\text{min} \cdot \text{cm}^2$  (fig. 17, lower panel), suggesting enhanced sweating when dehydration at rest precedes drinking during exercise.

Thigh sweat rate at rest (time zero) was slightly higher than forearm sweat rate (fig. 18, upper panel): it varied from  $0.05 \pm 0.02 \text{ mg}/\text{min} \cdot \text{cm}^2$  (OP1) to  $0.20 \pm 0.03 \text{ mg}/\text{min} \cdot \text{cm}^2$  (P2GP1). Rates began to increase after 5 min of exercise to reach  $0.46 \pm 0.05 \text{ mg}/\text{min} \cdot \text{cm}^2$  (HA) to  $0.060 \pm 0.07 \text{ mg}/\text{min} \cdot \text{cm}^2$  (P2GP1). Change in thigh sweat rate followed a similar pattern; HAP1 increased least by  $0.34 \pm 0.04 \text{ mg}/\text{min} \cdot \text{cm}^2$ , and OP1 increased most by  $0.46 \pm 0.08 \text{ mg}/\text{min} \cdot \text{cm}^2$ , similar to the forearm sweating response. However, the change in 00 thigh rate was also increased similar to that of the OP1 rate, unlike the change in forearm sweating where 00 had the most attenuated rate.

**Body water balance and sweat rate**— Mean ( $\pm$ SE) body water balance for the six treatments was  $42 \pm 76 \text{ mL}$  at rest, and  $-650 \pm 81 \text{ mL}$  ( $p < 0.01$ ) during exercise (fig. 19). Treatments P1P1 and P2P1 resulted in greater positive balance and HAP1 had greater negative balance at rest, indicating increased sweating, whereas P2P1 had the greatest negative balance and P2GP1 and HAP1 the lesser negative balances during exercise, indicating reduced sweating (table 7). Treatments OP1 and 00 had virtually similar unchanged rest balances and negative exercise balances, indicating that the latter were not affected by consuming P1 (fig. 19).

**Temple and thigh skin blood velocity**— Mean ( $\pm$ SE) temple skin blood velocity (from an inactive area of the body) was constant at rest, and varied from  $0.35 \pm 0.05$  to  $0.62 \pm 0.07 \text{ Hz} \cdot 10^2$  among the subjects (fig. 20, upper panel). All temple velocities increased after 5 min of exercise and, after about 55 min, reached equilibrium between  $0.77 \pm 0.14$  and  $0.98 \pm 0.15 \text{ Hz} \cdot 10^2$ . Treatment HAP1 had the lowest ( $0.26 \pm 0.11 \text{ Hz} \cdot 10^2$ ) and OP1 the highest ( $0.50 \pm 0.13 \text{ Hz} \cdot 10^2$ ) increase in velocity at 70 min of exercise (fig. 20, lower panel). Because about 25% of body heat loss comes from the head, reduced

temple skin blood velocity indicates reduced heat transport in this region.

Mean ( $\pm$ SE) thigh skin blood velocity from an active area during exercise was constant at rest and varied from  $0.26 \pm 0.2$  to  $0.50 \pm 0.11 \text{ Hz} \cdot 10^2$  (fig. 21, upper panel). Unlike temple skin response, thigh skin velocity with three treatments increased within 5 min of the start of exercise and all treatment velocities increased to reach, again after about 55 min of exercise, equilibrium levels between  $0.61 \pm 0.11$  and  $0.93 \pm 0.42 \text{ Hz} \cdot 10^2$ . Treatment P2GP1 had the lowest ( $0.22 \pm 0.16 \text{ Hz} \cdot 10^2$ ) and OP1 the highest ( $0.64 \pm 0.39 \text{ Hz} \cdot 10^2$ ) increase in thigh skin velocity at 70 min of exercise (fig. 21, lower panel); in fact, OP1 blood velocity was elevated appreciably throughout the exercise period.

### Salient Responses from Each Treatment

#### P1P1

1. Significant increase in plasma volume at rest
2. Showed the only positive exercise urinary free water clearance
3. Lowest change in exercise heart rate
4. Lowest change in exercise rectal temperature

#### P2P1

1. No effect of double strength [P1] on rest or exercise plasma volume
2. Low exercise urinary volume
3. Highest positive water balance at rest
4. Greatest negative exercise water balance

#### HAPI

1. Significant increase in plasma volume at rest
2. Highest level of exercise plasma volume
3. Highest level of rest and exercise plasma sodium, potassium, and osmotic content
4. Lowest plasma glucose concentration and content at rest
5. High exercise plasma glucose content in spite of no glucose intake
6. High exercise urinary volume
7. Highest rest and exercise urinary sodium excretion
8. Highest exercise urinary potassium and osmotic excretion

9. Lower rest and exercise urinary free water clearance
10. Greatest change (increase) in exercise heart rate
11. Least change in exercise thigh sweat rate
12. Showed the only negative water balance at rest
13. Least change in exercise temple skin blood flow

#### P2GP1

1. No effect of glycerol on rest or exercise plasma volume
2. Higher urinary volume at rest
3. Greatest change (increase) in exercise rectal temperature
4. Least change in exercise thigh skin blood flow

#### OP1

1. Compared with no drinking, P1 increased plasma volume
2. Highest exercise plasma glucose content
3. Low rest and exercise urinary volume
4. Lower rest and exercise urinary free water clearance
5. Greatest change (increase) in exercise heart rate
6. Greatest change (increase) in exercise forearm sweat rate
7. Greatest change (increase) in exercise thigh sweat rate
8. Greatest change (increase) in exercise temple skin blood flow
9. Greatest change in exercise thigh skin blood flow

#### 00

1. Low rest and exercise urinary volume
2. Lower rest and exercise urinary free water clearance
3. Least change (increase) in exercise forearm sweat rate

### Conclusion

HyperAde ( $164 \text{ mEq/L Na}^+$ ), with the lowest osmolality of the four fluid formulations, maintained plasma volume at rest and during exercise, whereas the other formulations with low  $\text{Na}^+$  and higher osmolality ( $365$  to  $1,382 \text{ mOsm/kg}$ ) did not. However, Performance 1 increased plasma volume at rest. Thus, drink composition appears to be more important than drink osmolality for increasing plasma volume at rest and

for maintaining it during moderately heavy submaximal exercise.

## References

- Adolph, E. F.; and Associates: *Physiology of Man in the Desert*. New York: Interscience, 1947.
- Bartlett, F.: *Psychological Criteria of Fatigue*. In *Symposium on Fatigue*, edited by W.F. Floyd and A.T. Welford. London: H. K. Lewis, 1953, pp. 1-5.
- Booth, D. A.: *Influences on Human Fluid Consumption*. In *Thirst: Physiological and Psychological Aspects*, edited by D. J. Ramsay and D. Booth. Chap. 4. New York: Springer-Verlag, 1991, pp. 53-73.
- Campbell, T. J.; Frohman, B.; and Reeve, E. B.: A Simple, Rapid, and Accurate Method of Extracting T-1824 from Plasma Adapted to the Routine Measurement of Blood Volume. *J. Lab. Clin. Med.* 52(5): 768-777, 1958.
- Castle, B. L.; and Greenleaf, J. E.: *Exercise Temperature Regulation in Man During Hypohydration and Hyperhydration*. *J. Appl. Physiol.* 30: 847-853, 1971.
- Fitts, R. H.: *Cellular Mechanisms of Muscle Fatigue*. *Physiol. Rev.* 74(1): 49-94, 1994.
- Gisolfi, C. V.: *Use of Electrolytes in Fluid Replacement Solutions: What Have We Learned from Intestinal Absorption Studies?* In *Fluid Replacement and Heat Stress*, edited by B.M. Marriott. Washington, D.C.: National Academy Press, 1991, pp. 11-21.
- Greenleaf, J. E.: *Effects of Dehydration on Performance in Man: Annotated Bibliography*. NASA TM X-62,308, 1973.
- Greenleaf, J. E.: *Hyperthermia and Exercise*. In *Int. Rev. Physiol.*, vol. 20, *Environmental Physiology III*, edited by D. Robertshaw. Baltimore: University Park Press, 1979, pp. 157-208.
- Greenleaf, J. E.: *The Consequences of Exercise on Thirst and Fluid Intake*. In *Thirst: Physiological and Psychological Aspects*, edited by D. J. Ramsay and D. Booth, Chap. 27. New York: Springer-Verlag, 1991, pp. 412-421.
- Greenleaf, J. E.: *Problem: Thirst, Drinking Behavior, and Involuntary Dehydration*. *Med. Sci. Sports Exerc.* 24(6): 645-656, 1992.
- Greenleaf, J. E.; and Castle, B. L.: *External Auditory Canal Temperature as an Estimate of Core Temperature*. *J. Appl. Physiol.* 32: 194-198, 1972.
- Greenleaf, J. E.; Convertino, V. A.; and Mangseth, G. R.: *Plasma Volume During Stress in Man: Osmolality and Red Cell Volume*. *J. Appl. Physiol.* 47: 1031-1038, 1979.
- Greenleaf, J. E.; Geelen, G.; Jackson, C. G. R.; Saumet, J.-L.; Juhos, L. T.; Keil, L. C.; Fegan-Mayer, D.; Dearborn, A.; Hinghofer-Szalkay, H.; and Whittam, J. H.: *Vascular Uptake of Rehydration Fluids in Hypohydrated Men at Rest and Exercise*. NASA TM 103942, 1992.
- Greenleaf, J. E.; and Williams, B. A.: *Thermistor Holder for Skin Temperature Measurements*. U.S. Patent 3,983,753; NASA-CASE-ARC-10855-1, 1976.
- Hardy, J. D.; and Dubois, E. F.: *Technic of Measuring Radiation and Convection*. *J. Nutr.* 15: 461-475, 1938.
- Kozlowski, S.; Greenleaf, J. E.; Turlejaska, E.; and Nazar, K.: *Extracellular Hyperosmolality and Body Temperature During Physical Exercise in Dogs*. *Am. J. Physiol.* 239: R180-R183, 1980.
- Luetkemeier, M. J.; and Thomas, E. L.: *Hypervolemia and Cycling Time Trial Performance*. *Med. Sci. Sports Exerc.* 26(4): 503-509, 1994.
- Marriott, B. M. (editor): *Fluid Replacement and Heat Stress*. Washington D.C.: National Academy Press, 1994.
- Maughan, R. J.; and Noakes, T. D.: *Fluid Replacement and Exercise Stress. A Brief Review of Studies on Fluid Replacement and Some Guidelines for the Athlete*. *Sports Med.* 12(1): 16-31, 1991.
- Murray, R.: *The Effects of Consuming Carbohydrate-Electrolyte Beverages on Gastric Emptying and Fluid Absorption During and Following Exercise*. *Sports Med.* 4(5): 322-351, 1987.
- Pitts, G. C.; Johnson, R. E.; and Consolazio, F. C.: *Work in the Heat as Affected by Intake of Water, Salt and Glucose*. *Am J. Physiol.* 142: 253-259, 1944.
- Rothstein, A.; Adolph, E. F.; and Wills, J. H.: *Voluntary Dehydration*. In *Physiology of Man in the Desert*, edited by E. F. Adolph and Associates. New York: Interscience, 1947, pp. 254-270.
- Spaul, W. A.: *Physiological Effects of Simultaneous Exposures to Heat and Vibration*. Ph.D. Thesis, Univ. of Calif., Berkeley; NASA TM 84400, 1983.

Table 1. Anthropometric and peak exercise data for the six subjects

| Anthropometric data |         |            |            |                              |                   |                  |                     |                |             | Peak exercise data       |                   |               |                   |                            |  |
|---------------------|---------|------------|------------|------------------------------|-------------------|------------------|---------------------|----------------|-------------|--------------------------|-------------------|---------------|-------------------|----------------------------|--|
| Subject             | Age, yr | Height, cm | Weight, kg | Surface area, m <sup>2</sup> | Plasma volume, mL | Blood volume, mL | Blood volume, mL/kg | Load, kg-m/min | STPD, L/min | Ventilation, BTPS, L/min | Heart rate, b/min | Oxygen, L/min | Uptake, mL/min/kg | Respiratory exchange ratio |  |
| CAL                 | 24      | 186        | 67.20      | 1.90                         | 3240              | 5598             | 83                  | 1400           | 104.24      | 125.50                   | 193               | 2.64          | 39                | 1.34                       |  |
| DUW                 | 39      | 192        | 97.74      | 2.28                         | 4112              | 7373             | 75                  | 1700           | 109.85      | 132.04                   | 162               | 2.92          | 30                | 1.11                       |  |
| GUF                 | 36      | 170        | 57.42      | 1.66                         | 2551              | 4620             | 80                  | 1500           | 98.60       | 118.71                   | 170               | 2.61          | 45                | 1.33                       |  |
| PAU                 | 23      | 182        | 89.20      | 2.11                         | 2899              | 5338             | 60                  | 1700           | 123.85      | 148.62                   | 199               | 3.55          | 40                | 1.24                       |  |
| PED                 | 22      | 181        | 63.72      | 1.82                         | 3215              | 5591             | 88                  | 1800           | 85.91       | 103.09                   | 210               | 3.56          | 56                | 1.19                       |  |
| REA                 | 34      | 183        | 85.75      | 2.08                         | 2729              | 4615             | 54                  | 1200           | 106.50      | 128.01                   | 187               | 2.64          | 31                | 1.27                       |  |
| $\bar{X}$           | 30      | 182        | 76.84      | 1.98                         | 3124              | 5522             | 73                  | 1550           | 104.83      | 126.00                   | 187               | 2.99          | 40                | 1.25                       |  |
| $\pm$ SD            | 8       | 7          | 16.19      | 0.22                         | 505               | 923              | 12                  | 226            | 12.54       | 15.04                    | 17                | 0.45          | 10                | 0.09                       |  |
| $\pm$ SE            | 3       | 3          | 6.61       | 0.09                         | 206               | 377              | 5                   | 92             | 5.12        | 6.14                     | 7                 | 0.19          | 4                 | 0.04                       |  |

STPD = standard temperature, pressure, dry.

BTPS = body temperature, pressure, saturated.

Table 2. Drink composition per 2000 mL (package label data)

|                                               | P1 <sup>b</sup> | P2 <sup>c</sup> | P2G <sup>d</sup> | HA <sup>e</sup> |
|-----------------------------------------------|-----------------|-----------------|------------------|-----------------|
| Sodium chloride (gm)                          | -               | -               | -                | 9.00            |
| Sodium Citrate (gm)                           | 3.87            | 7.74            | 7.74             | 15.44           |
| Dextrose (gm)                                 | 41.12           | 82.24           | 82.24            | -               |
| Aspartame (gm)                                | -               | -               | -                | 0.72            |
| Glycerol (gm)                                 | -               | -               | 100.87           | -               |
| Shaklee Performance <sup>a</sup> (gm)         | 222.28          | 444.56          | 444.56           | -               |
| Total                                         | 222.28          | 444.56          | 444.56           | 25.16           |
| Total volume (mL)                             | 2,000           | 2,000           | 2,000            | 2,000           |
| Ionic concentration: (mEq/L, % weight/volume) |                 |                 |                  |                 |
| Na <sup>+</sup>                               | 19.61/0.04      | 39.22/0.09      | 39.22/0.09       | 157/0.36        |
| K <sup>+</sup>                                | 5.01/0.02       | 10.02/0.04      | 10.02/0.04       | -               |
| Cl <sup>-</sup>                               | 4.98/0.02       | 9.96/0.04       | 9.96/0.04        | 76/0.27         |
| Mg <sup>++</sup>                              | 0.40/0.01       | 0.80/0.01       | 0.80/0.01        | -               |
| Ca <sup>++</sup>                              | 1.96/0.02       | 3.92/0.03       | 3.92/0.03        | -               |
| P <sup>++++</sup>                             | 0.51/0.01       | 1.02/0.02       | 1.02/0.02        | -               |
| Total                                         | 32.47/0.11      | 69.94/0.22      | 69.94/0.22       | 233/0.63        |
| Carbohydrate (% weight/volume)                |                 |                 |                  |                 |
| Glucose                                       | 1.85            | 3.70            | 3.70             | -               |
| Fructose                                      | 2.43            | 4.85            | 4.85             | -               |
| Maltodextrin                                  | 5.44            | 10.88           | 10.88            | -               |
| Total                                         | 9.72            | 19.43           | 19.43            | -               |
| Measured drink solute concentrations          |                 |                 |                  |                 |
| Na <sup>+</sup> (mEq/L)                       | 55.2            | 97.1            | 112.7            | 163.7           |
| K <sup>+</sup> (mEq/L)                        | 5.3             | 10.3            | 10.7             | <0.1            |
| Osmolality (mOsm/kgH <sub>2</sub> O)          | 365             | 791             | 1382             | 253             |
| Glycerol (mg/dL)                              | 2.0             | 4.0             | 2916             | 1.0             |
| Glucose (mg/dL)                               | 2049            | 3579            | 3543             | <0.5            |
| Citrate (mg/dL)                               | 416             | 753             | 731              | 854             |

<sup>a</sup>Shaklee U.S., Inc., San Francisco, CA 94111.

<sup>b</sup>Shaklee Performance.

<sup>c</sup>Double-strength Shaklee Performance.

<sup>d</sup>Double-strength Shaklee Performance plus 80 mL glycerol.

<sup>e</sup>HyperAde -NaCl/Na citrate (0.036% Na<sup>+</sup>)

Table 3. Individual drink volume (10 mL/kg body weight) for the rest and exercise phases

| Drink     | P1P1  | P2P1  | P2GP1 | HAP1  | OP1 | 0 |
|-----------|-------|-------|-------|-------|-----|---|
| Subject   |       |       |       |       |     |   |
| CAL       | 1,342 | 1,342 | 1,318 | 1,346 | 656 | 0 |
| DUW       | 1,978 | 2,018 | 2,000 | 1,984 | 977 | 0 |
| GUF       | 1,112 | 1,092 | 1,106 | 1,102 | 561 | 0 |
| PAU       | 1,800 | 1,785 | 1,794 | 1,812 | 892 | 0 |
| PED       | 1,264 | 1,274 | 1,266 | 1,268 | 627 | 0 |
| REA       | 1,708 | 1,696 | 1,722 | 1,720 | 866 | 0 |
| $\bar{X}$ | 1,534 | 1,535 | 1,534 | 1,539 | 796 | 0 |
| $\pm$ SD  | 342   | 353   | 353   | 348   | 164 | 0 |
| $\pm$ SE  | 140   | 144   | 144   | 142   | 67  | 0 |

Table 4. Individual subject rest and submaximal exercise data<sup>a</sup>

| Subject   | $\dot{V}O_2$ rest,<br>L/min | Load, <sup>a</sup><br>kg-m/min | $\dot{V}O_2$ exercise, <sup>a</sup><br>L/min | $\dot{V}O_2$ exercise, <sup>a</sup><br>% peak | $\dot{V}O_2$ exercise, <sup>a</sup><br>mL/min · kg |
|-----------|-----------------------------|--------------------------------|----------------------------------------------|-----------------------------------------------|----------------------------------------------------|
| CAL       | 0.34                        | 700                            | 1.80                                         | 68                                            | 27                                                 |
| DUW       | 0.44                        | 900                            | 2.43                                         | 83                                            | 25                                                 |
| GUF       | 0.31                        | 700                            | 1.70                                         | 65                                            | 30                                                 |
| PAU       | 0.44                        | 900                            | 2.46                                         | 69                                            | 28                                                 |
| PED       | 0.38                        | 1000                           | 2.19                                         | 62                                            | 34                                                 |
| REA       | 0.40                        | 700                            | 1.90                                         | 72                                            | 22                                                 |
| $\bar{X}$ | 0.39                        | 817                            | 2.08                                         | 70                                            | 28                                                 |
| $\pm$ SD  | 0.05                        | 133                            | 0.33                                         | 7                                             | 4                                                  |
| $\pm$ SE  | 0.02                        | 54                             | 0.13                                         | 3                                             | 2                                                  |

<sup>a</sup>  $\bar{X}$  of six treatments.

$\dot{V}O_2$  = oxygen uptake.

Table 5. Mean environmental parameters for the six treatments

| Variable                   |           | P1P1  | P2P1  | P2GP1 | HAP1  | OP1   | 00    | Mean  |
|----------------------------|-----------|-------|-------|-------|-------|-------|-------|-------|
| <b>Rest phase</b>          |           |       |       |       |       |       |       |       |
| Dry bulb temperature (°C)  | $\bar{X}$ | 22.2  | 21.9  | 21.4  | 21.8  | 22.1  | 21.4  | 21.8  |
|                            | $\pm$ SD  | 0.9   | 1.1   | 0.5   | 0.8   | 0.6   | 0.2   | 0.3   |
|                            | $\pm$ SE  | 0.4   | 0.4   | 0.2   | 0.3   | 0.3   | 0.1   | 0.1   |
| Relative humidity (%)      | $\bar{X}$ | 50    | 48    | 45    | 48    | 52    | 51    | 49    |
|                            | $\pm$ SD  | 5     | 5     | 1     | 4     | 6     | 2     | 3     |
|                            | $\pm$ SE  | 2     | 2     | 1     | 2     | 3     | 1     | 1     |
| Wind speed (ft/min)        | $\bar{X}$ | 23    | 16    | 25    | 25    | 29    | 22    | 23    |
|                            | $\pm$ SD  | 8     | 8     | 8     | 7     | 12    | 5     | 4     |
|                            | $\pm$ SE  | 3     | 3     | 3     | 3     | 5     | 2     | 2     |
| Barometric pressure (mmHg) | $\bar{X}$ | 764.3 | 764.3 | 763.1 | 764.1 | 762.5 | 763.5 | 763.6 |
|                            | $\pm$ SD  | 1.0   | 2.0   | 1.8   | 0.7   | 0.9   | 2.2   | 0.7   |
|                            | $\pm$ SE  | 0.4   | 0.8   | 0.8   | 0.3   | 0.4   | 0.9   | 0.3   |
| <b>Exercise phase</b>      |           |       |       |       |       |       |       |       |
| Dry bulb temperature (°C)  | $\bar{X}$ | 22.2  | 21.8  | 21.0  | 21.6  | 22.2  | 21.9  | 21.8  |
|                            | $\pm$ SD  | 0.8   | 1.2   | 0.3   | 0.5   | 0.6   | 0.3   | 0.4   |
|                            | $\pm$ SE  | 0.3   | 0.5   | 0.1   | 0.2   | 0.2   | 0.1   | 0.2   |
| Relative humidity (%)      | $\bar{X}$ | 49    | 49    | 46    | 51    | 52    | 51    | 50    |
|                            | $\pm$ SD  | 5     | 2     | 3     | 1     | 5     | 3     | 2     |
|                            | $\pm$ SE  | 2     | 1     | 1     | 1     | 2     | 1     | 1     |
| Wind speed (ft/min)        | $\bar{X}$ | 53    | 60    | 49    | 54    | 52    | 52    | 53    |
|                            | $\pm$ SD  | 6     | 15    | 5     | 1     | 6     | 6     | 4     |
|                            | $\pm$ SE  | 3     | 6     | 2     | 1     | 3     | 3     | 2     |
| Barometric pressure (mmHg) | $\bar{X}$ | 764.0 | 764.1 | 763.2 | 764.0 | 762.2 | 763.7 | 763.5 |
|                            | $\pm$ SD  | 1.2   | 1.7   | 1.9   | 0.8   | 1.0   | 2.4   | 0.7   |
|                            | $\pm$ SE  | 0.5   | 0.7   | 0.8   | 0.3   | 0.4   | 1.0   | 0.3   |

Rest phase data are averages of -65- and -35-min values; exercise phase data are averages of 30- and 60-min values.

Table 6. Mean ( $\pm$ SE) urine electrolyte concentrations for the rest (-105 to -15 min) and exercise (-15 to +10 min) phases for the six treatments

| Variable                             | P1P1           | P2P1           | P2GP1          | HAP1            | OP1             | 00              |
|--------------------------------------|----------------|----------------|----------------|-----------------|-----------------|-----------------|
| <b>Rest phase</b>                    |                |                |                |                 |                 |                 |
| Urine Na <sup>+</sup> ( $\mu$ Eq/L)  | 63.3<br>(17.4) | 65.8<br>(17.5) | 81.1<br>(22.8) | 100.4<br>(18.6) | 113.1<br>(17.7) | 111.2<br>(21.7) |
| Urine K <sup>+</sup> ( $\mu$ Eq/L)   | 18.2<br>(4.1)  | 17.8<br>(4.5)  | 29.0<br>(8.0)  | 39.8<br>(8.2)   | 51.7<br>(14.1)  | 66.8<br>(22.1)  |
| Osmolality (mOsm/kgH <sub>2</sub> O) | 328<br>(56)    | 368<br>(62)    | 443<br>(121)   | 498<br>(79)     | 752<br>(146)    | 712<br>(135)    |
| <b>Exercise phase</b>                |                |                |                |                 |                 |                 |
| Urine Na <sup>+</sup> ( $\mu$ Eq/L)  | 47.6<br>(8.6)  | 72.9<br>(22.4) | 55.1<br>(7.8)  | 80.6<br>(19.9)  | 102.3<br>(12.2) | 126.5<br>(18.9) |
| Urine K <sup>+</sup> ( $\mu$ Eq/L)   | 27.4<br>(3.8)  | 53.6<br>(24.5) | 27.1<br>(2.1)  | 58.5<br>(6.2)   | 85.9<br>(13.4)  | 90.2<br>(19.2)  |
| Osmolality (mOsm/kgH <sub>2</sub> O) | 280<br>(33)    | 451<br>(124)   | 397<br>(87)    | 442<br>(89)     | 781<br>(116)    | 843<br>(105)    |

Table 7. Mean ( $\pm$ SE) water balance, respiratory water loss, insensible water loss, and sweat rate for the rest (-105 to -15 min) and exercise (-15 to 70 min) phases for the six treatments

| Variable                                      | P1P1         | P2P1         | P2GP1        | HAP1         | OP1          | 00           |
|-----------------------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|
| <b>Rest phase</b>                             |              |              |              |              |              |              |
| Water balance, g/m <sup>2</sup> · hr          | 47<br>(19)   | 93<br>(52)   | 1<br>(23)    | -78<br>(47)  | 6<br>(39)    | -23<br>(65)  |
| Respiratory water loss, g/m <sup>2</sup> · hr | 12<br>(1)    | 12<br>(1)    | 12<br>(1)    | 12<br>(1)    | 10<br>(1)    | 10<br>(1)    |
| Insensible water loss, g/m <sup>2</sup> · hr  | 18           | 18           | 18           | 18           | 18           | 18           |
| Sweat rate, g/m <sup>2</sup> · hr             | 77<br>(19)   | 123<br>(52)  | 31<br>(22)   | -48<br>(47)  | 34<br>(39)   | -5<br>(65)   |
| <b>Exercise phase</b>                         |              |              |              |              |              |              |
| Water balance, g/m <sup>2</sup> · hr          | -197<br>(42) | -315<br>(73) | -125<br>(34) | -151<br>(31) | -237<br>(73) | -221<br>(62) |
| Respiratory water loss, g/m <sup>2</sup> · hr | 49<br>(2)    | 50<br>(3)    | 52<br>(2)    | 49<br>(1)    | 50<br>(4)    | 49<br>(3)    |
| Insensible water loss, g/m <sup>2</sup> · hr  | 18           | 18           | 18           | 18           | 18           | 18           |
| Sweat rate, g/m <sup>2</sup> · hr             | 130<br>(40)  | 247<br>(72)  | 55<br>(34)   | 84<br>(30)   | 169<br>(71)  | 154<br>(59)  |

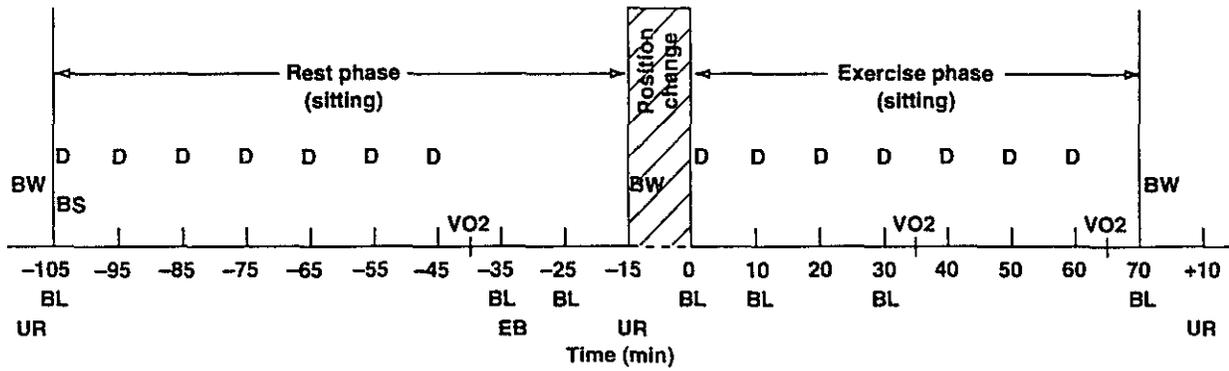


Figure 1. Experimental protocol. UR = urine, BL = blood sample, EB = Evans blue injection, BW = body weight,  $\dot{V}O_2$  = oxygen uptake, and D = drinking (1/14 of total volume).

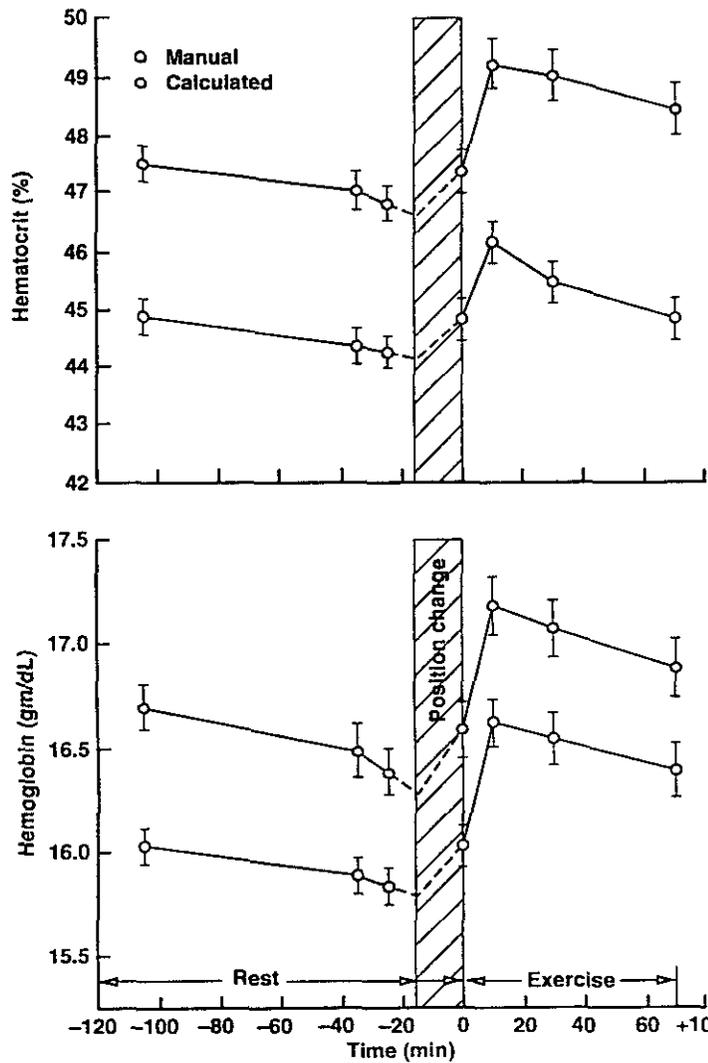


Figure 2. Comparison of manual and automatic (Coulter counter) measurement for hemoglobin and hematocrit at rest and during exercise ( $\bar{X} \pm SE$ ).

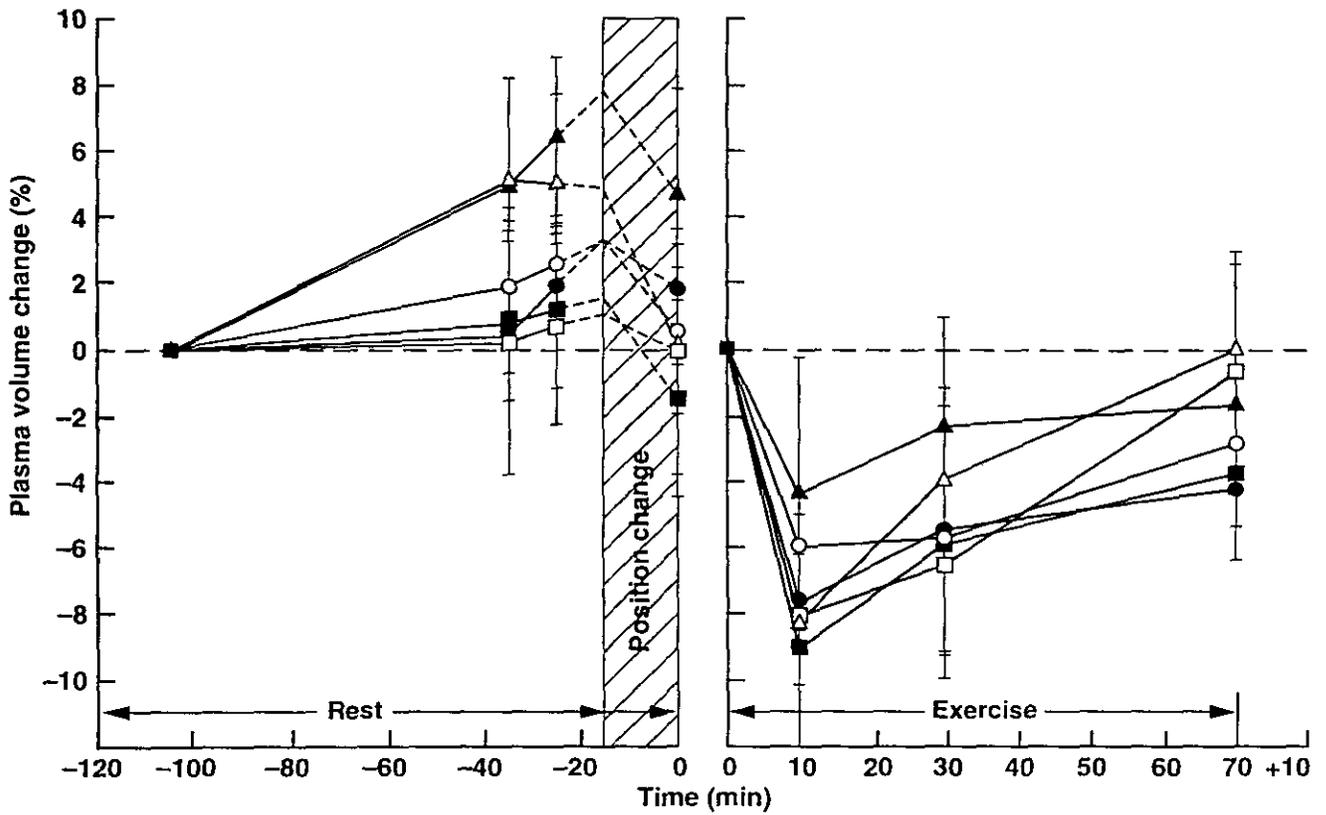
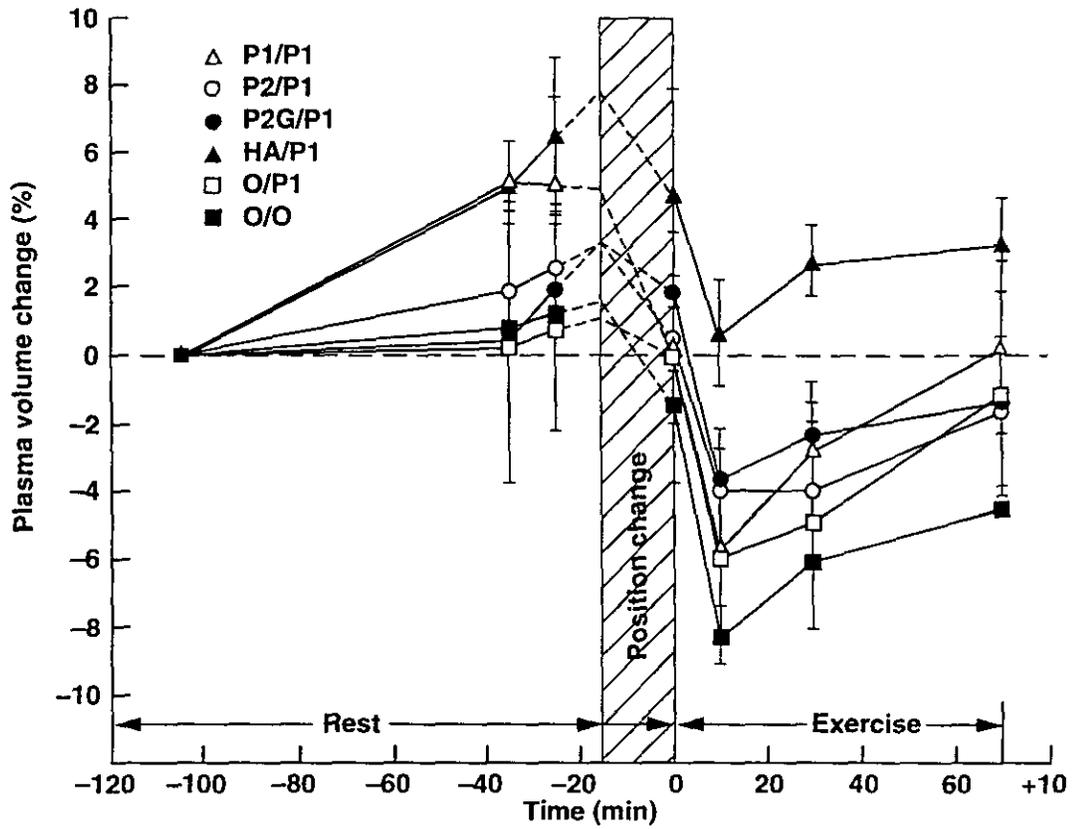


Figure 3. Mean ( $\pm$ SE) change in plasma volume at rest and during exercise for the six treatments.

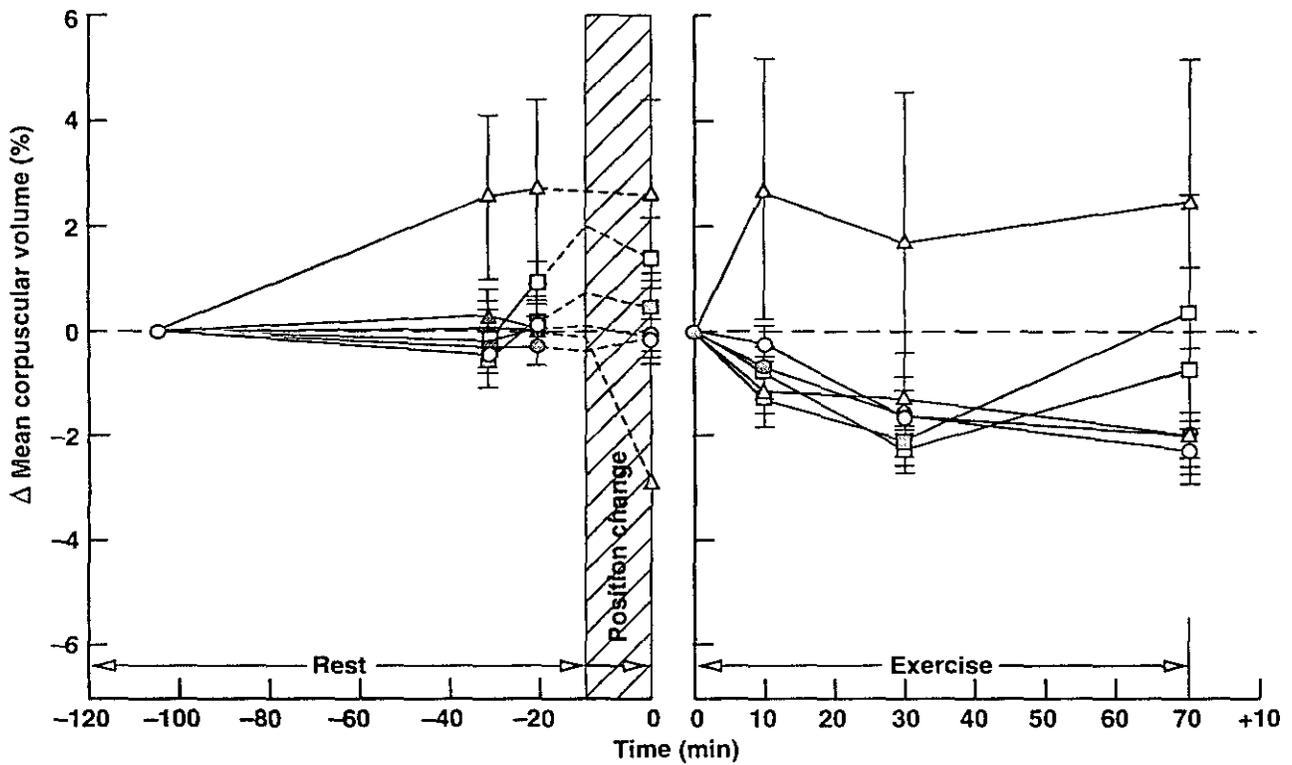
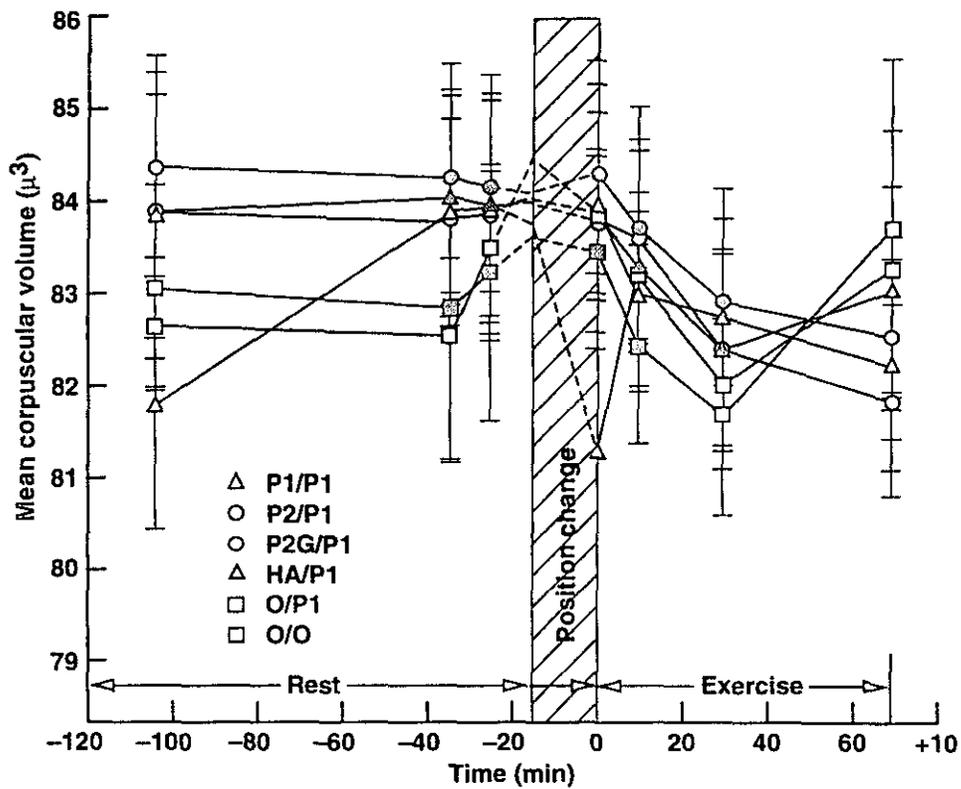


Figure 4. Mean ( $\pm$ SE) mean corpuscular volume at rest and during exercise for the six treatments.

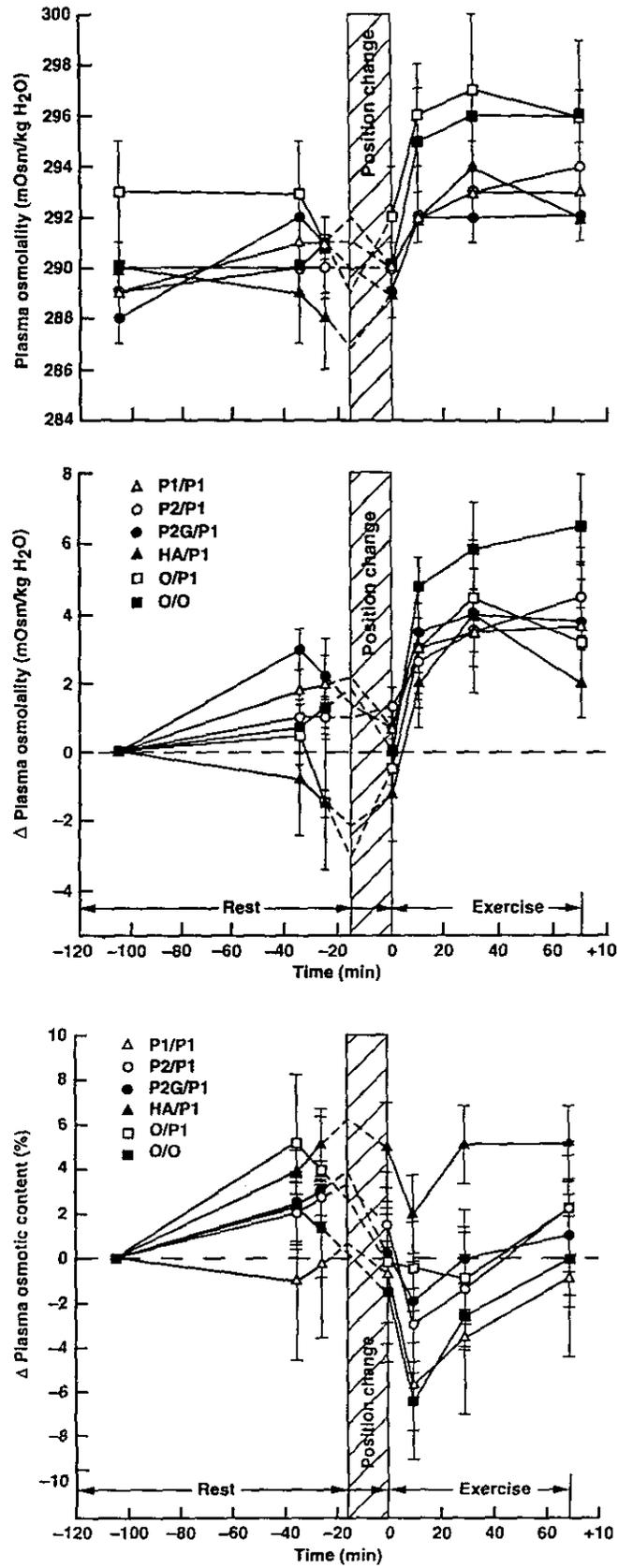


Figure 5. Mean ( $\pm$ SE) plasma osmotic concentration at rest and during exercise for the six treatments.

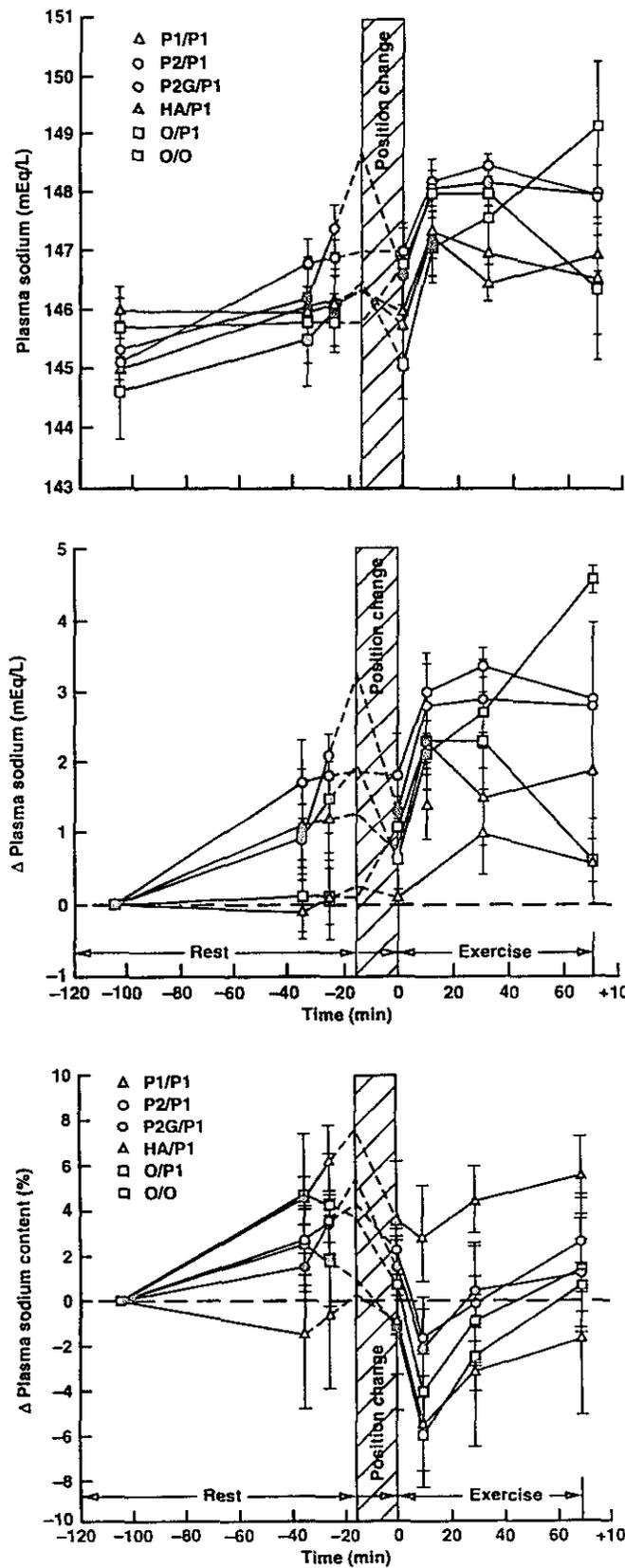


Figure 6. Mean ( $\pm$ SE) plasma sodium concentration at rest and during exercise for the six treatments.

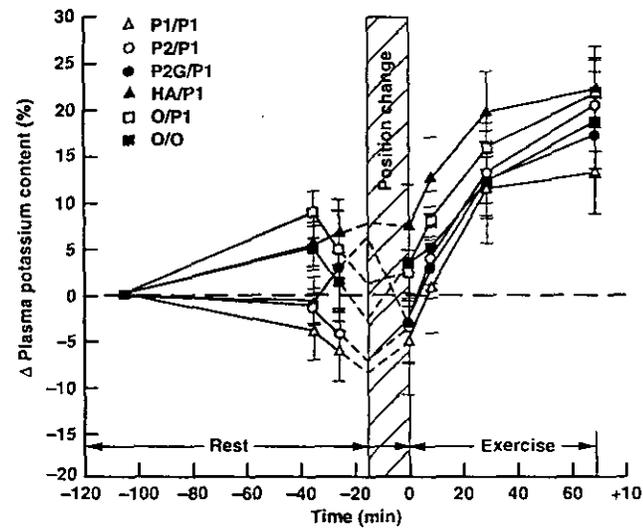
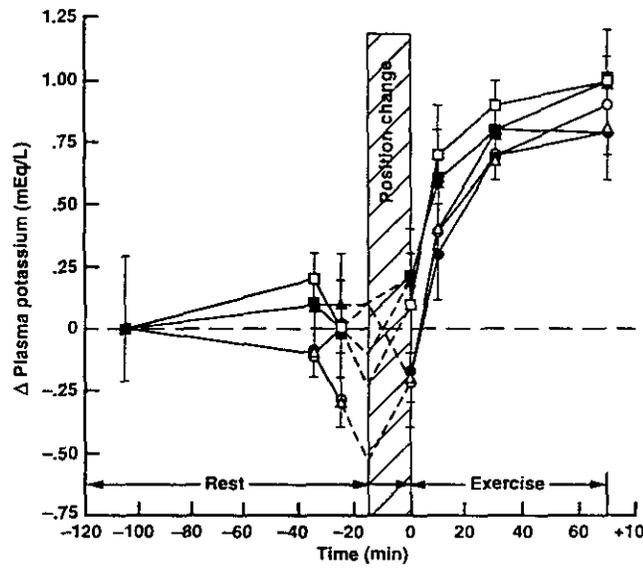
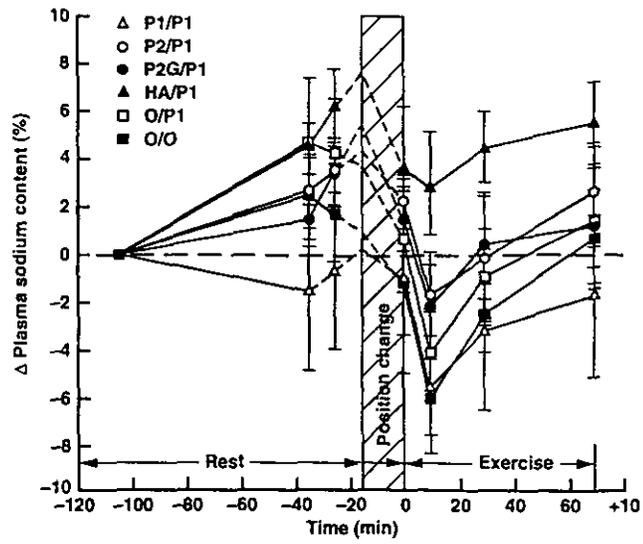


Figure 7. Mean ( $\pm$ SE) plasma potassium concentration at rest and during exercise for the six treatments.

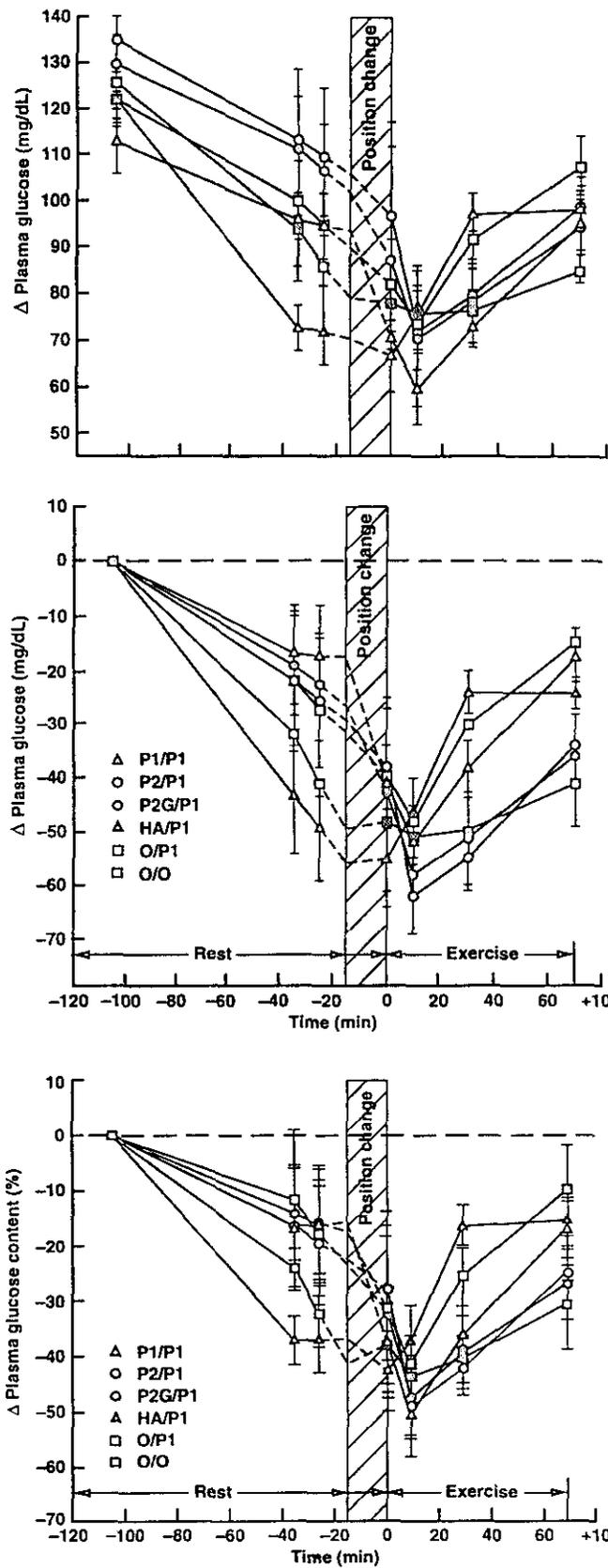


Figure 8. Mean ( $\pm$ SE) plasma glucose concentration at rest and during exercise for the six treatments.

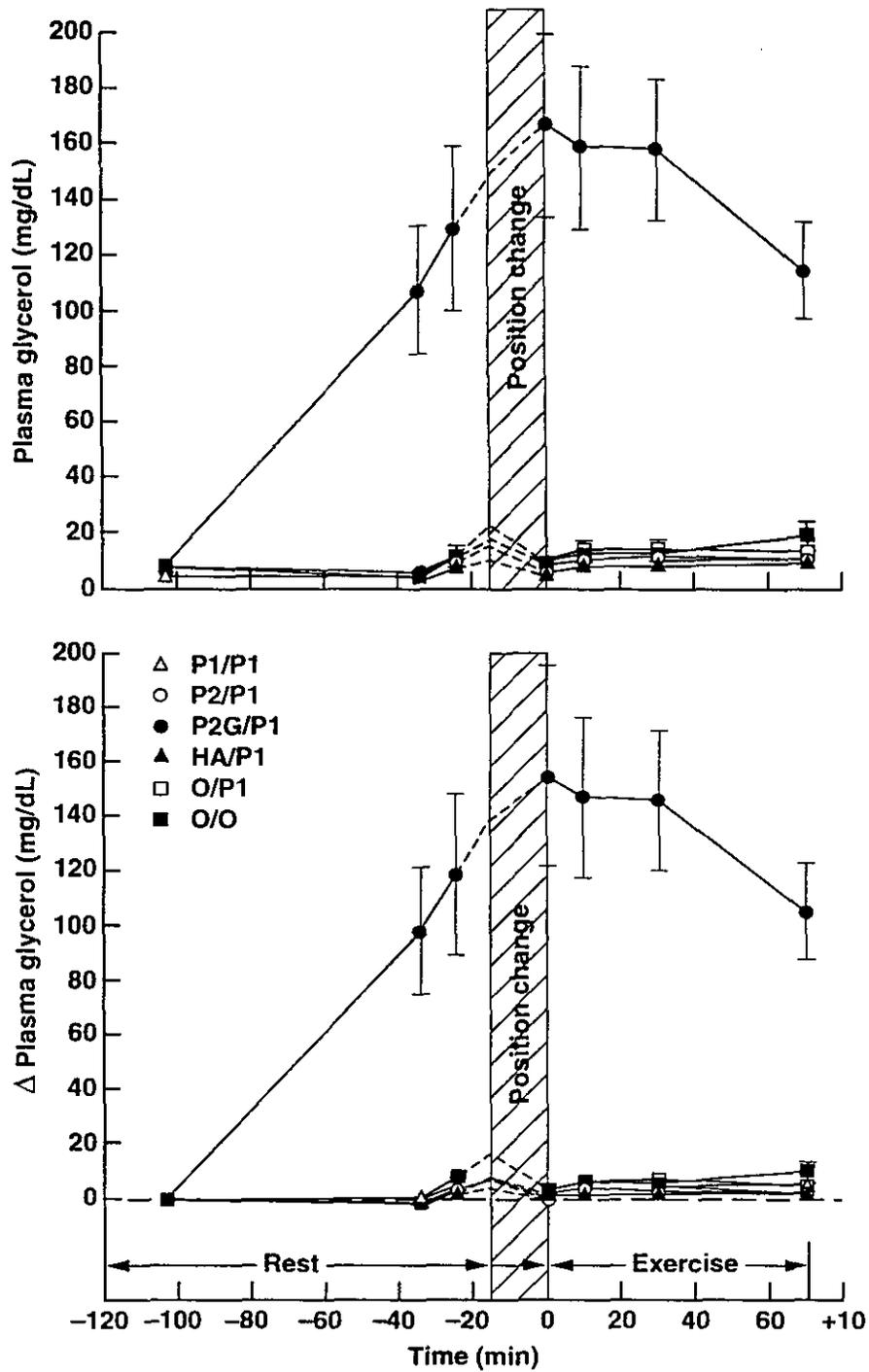


Figure 9. Mean ( $\pm$ SE) plasma glycerol concentration at rest and during exercise for the six treatments.

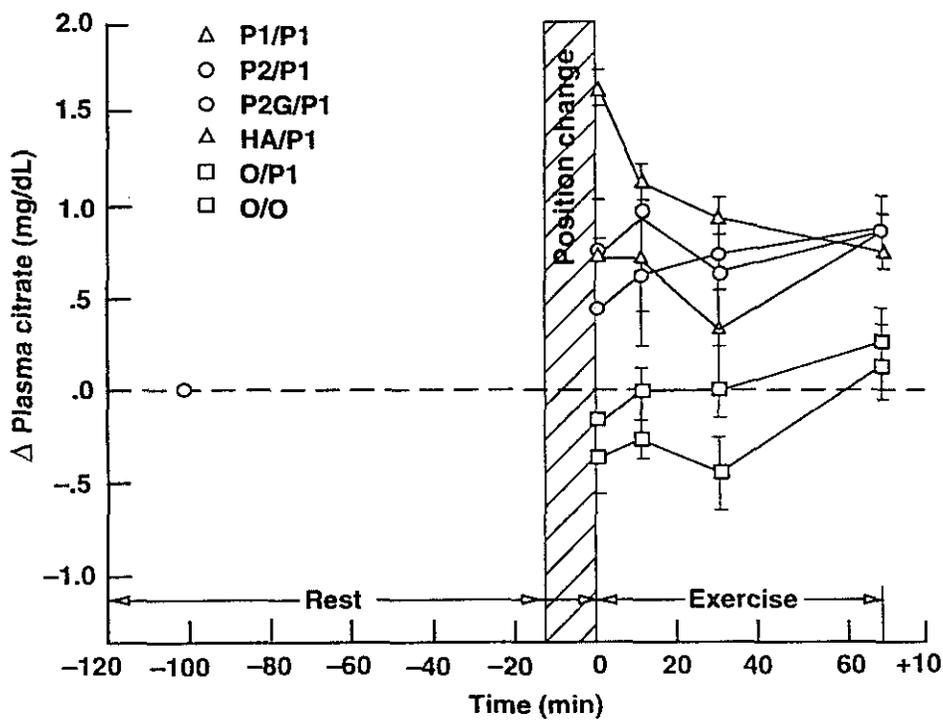
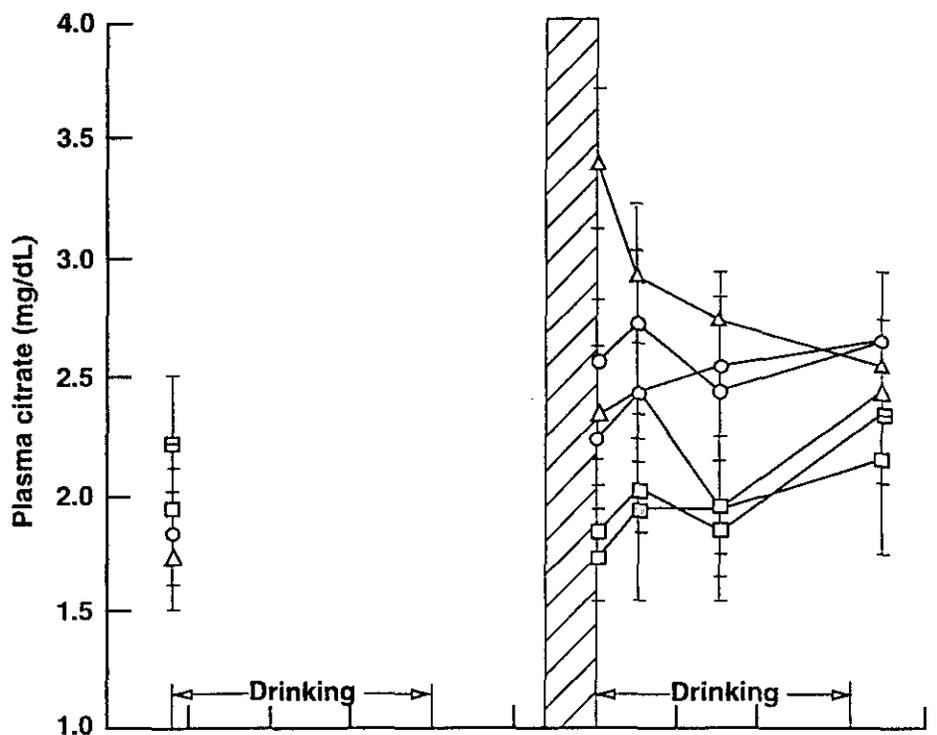


Figure 10. Mean ( $\pm$ SE) plasma citrate concentration at rest and during exercise for the six treatments.

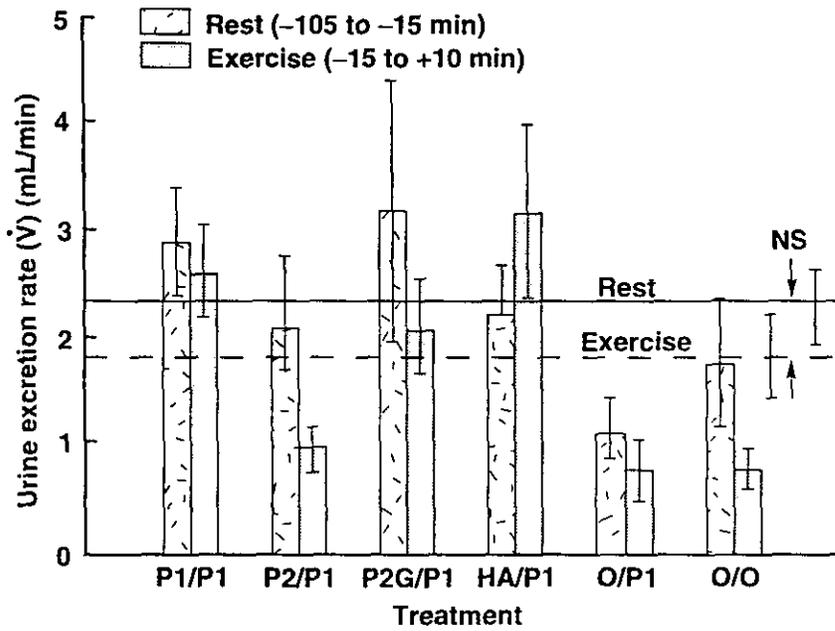


Figure 11. Mean ( $\pm$ SE) urinary excretion rate at rest and during exercise for the six treatments. Solid line is mean ( $\pm$ SE) for rest treatments; dash line is mean ( $\pm$ SE) for exercise treatments.

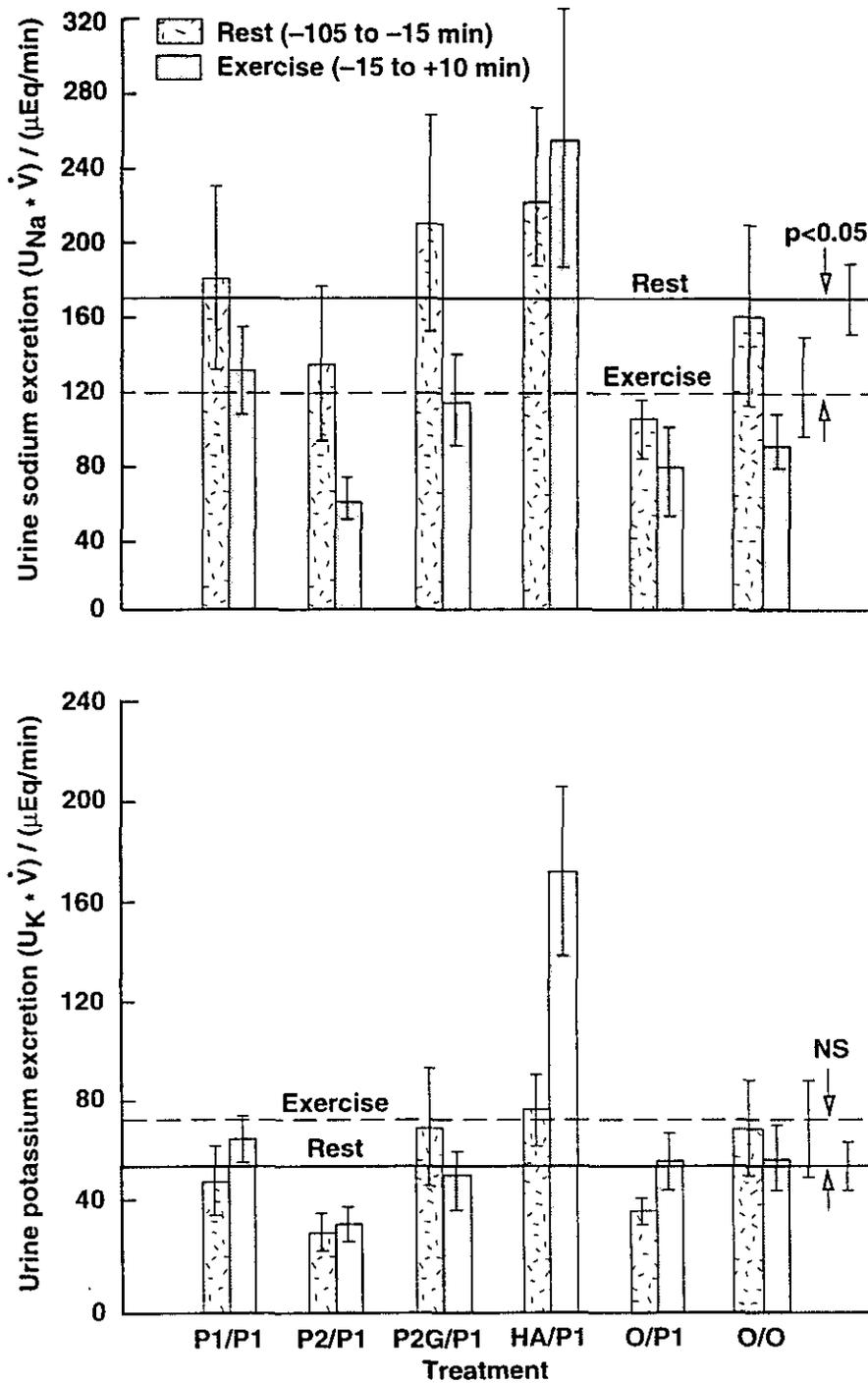


Figure 12. Mean ( $\pm$ SE) urine sodium excretion (upper panel) and potassium excretion (lower panel) at rest and during exercise for the six treatments.

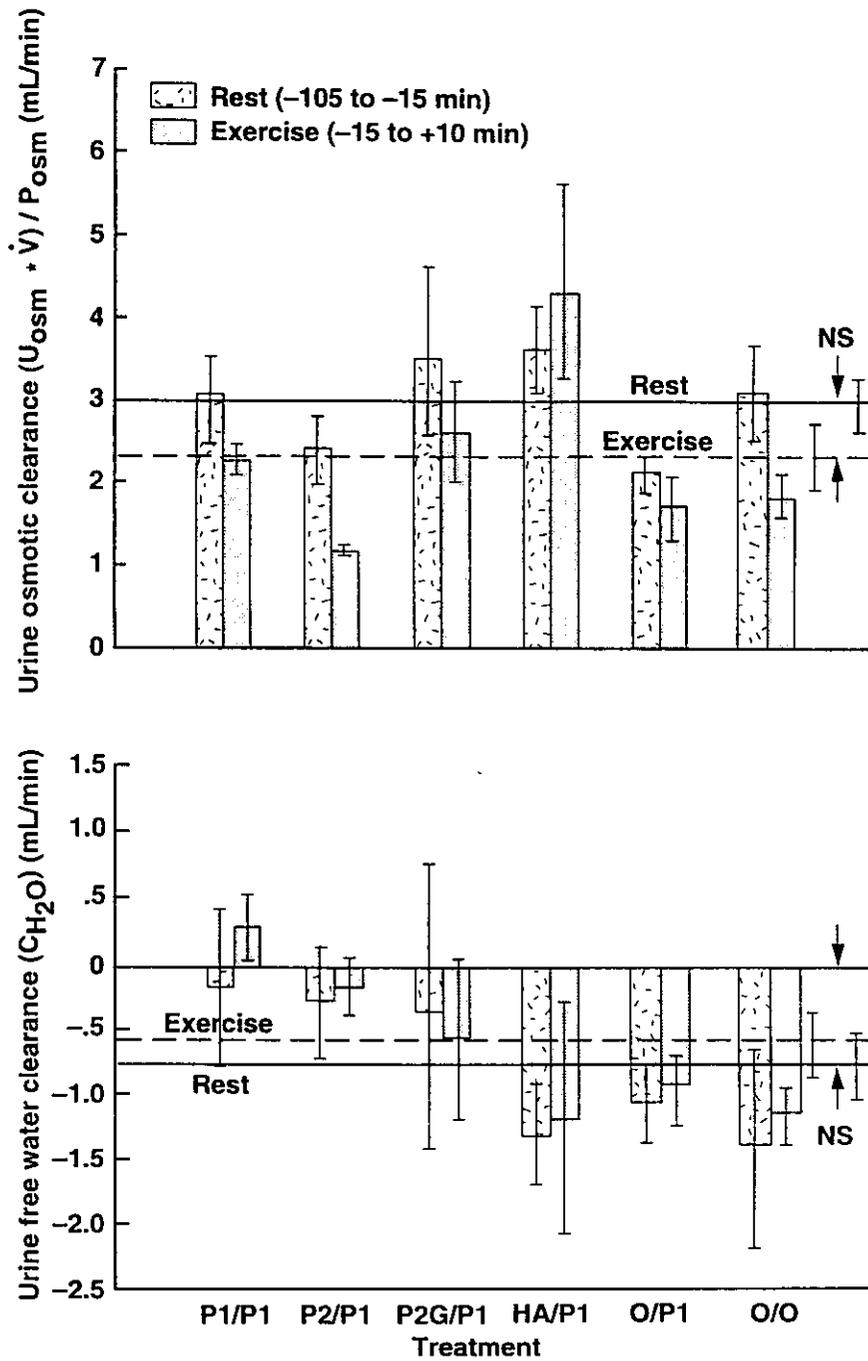


Figure 13. Mean ( $\pm$ SE) urine osmotic clearance (upper panel) and free water clearance (lower panel) at rest and during exercise for the six treatments.

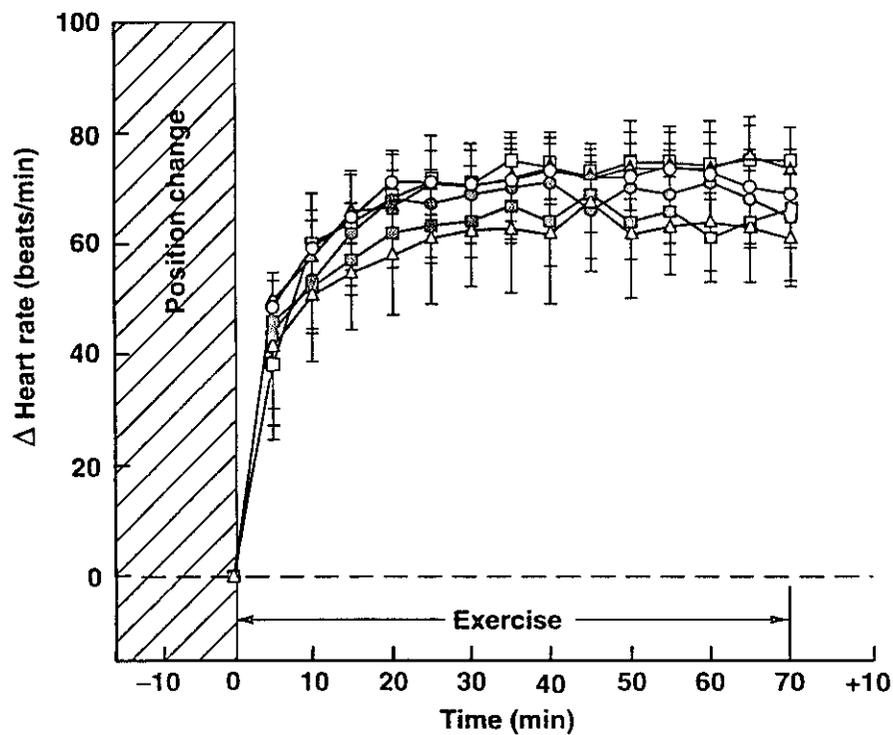
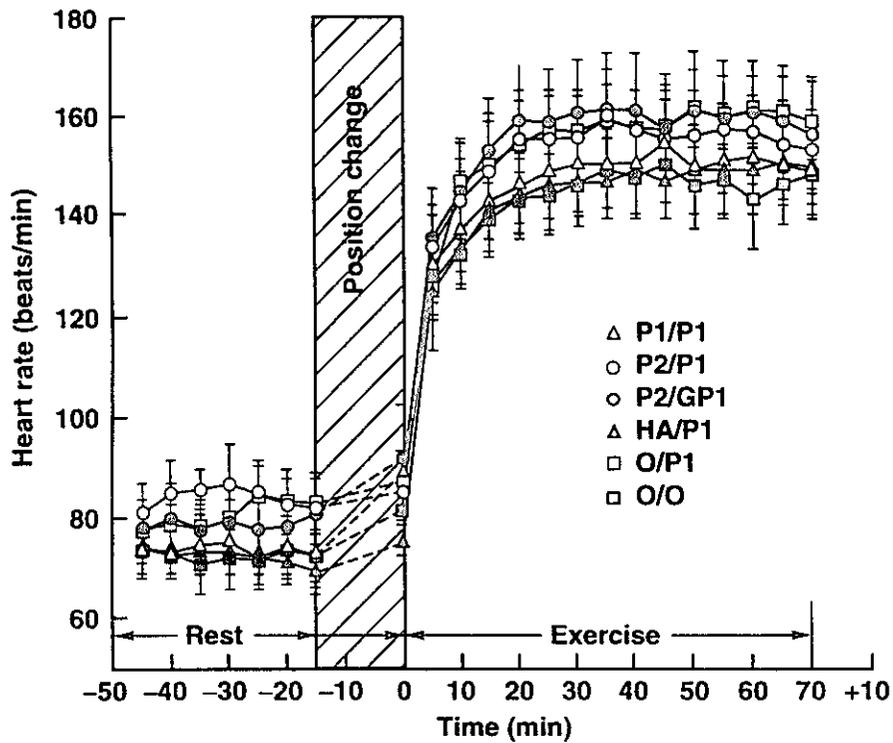


Figure 14. Mean ( $\pm$ SE) heart rate at rest and during exercise for the six treatments.

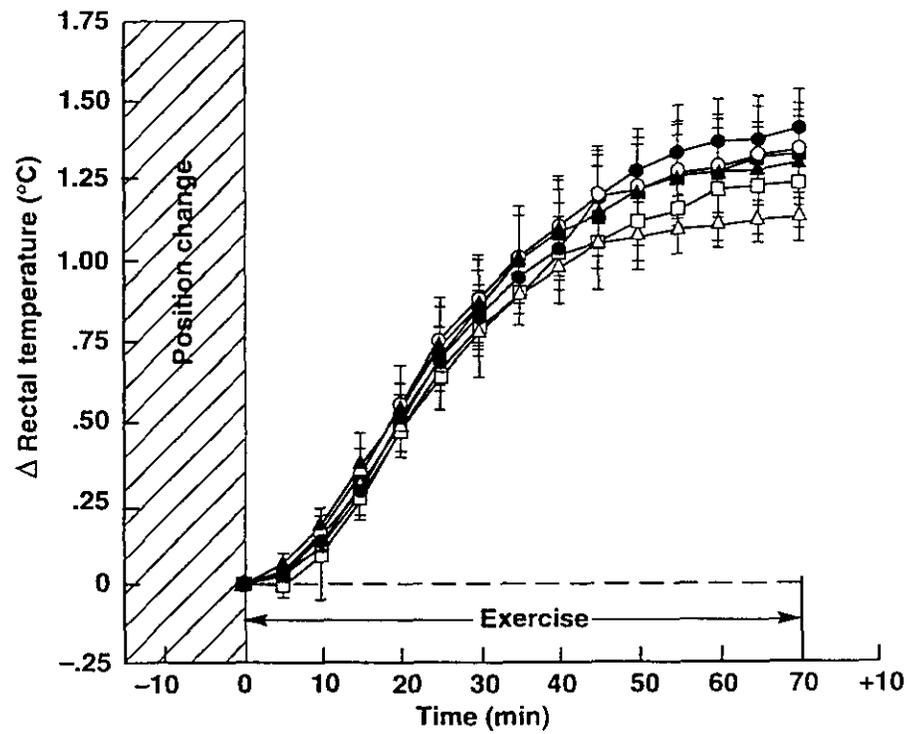
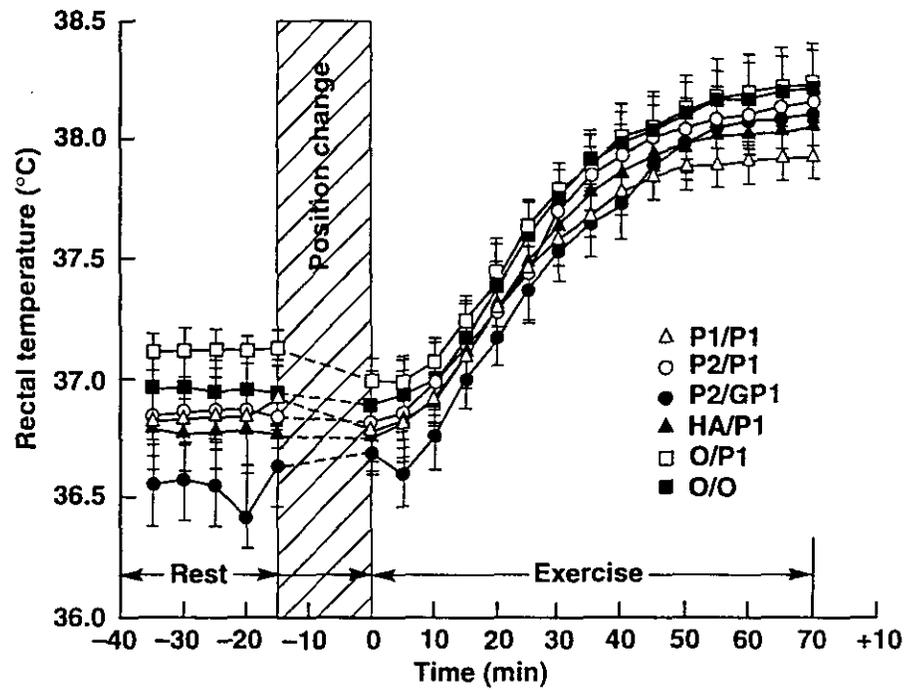


Figure 15. Mean ( $\pm$ SE) rectal temperature at rest and during exercise for the six treatments.

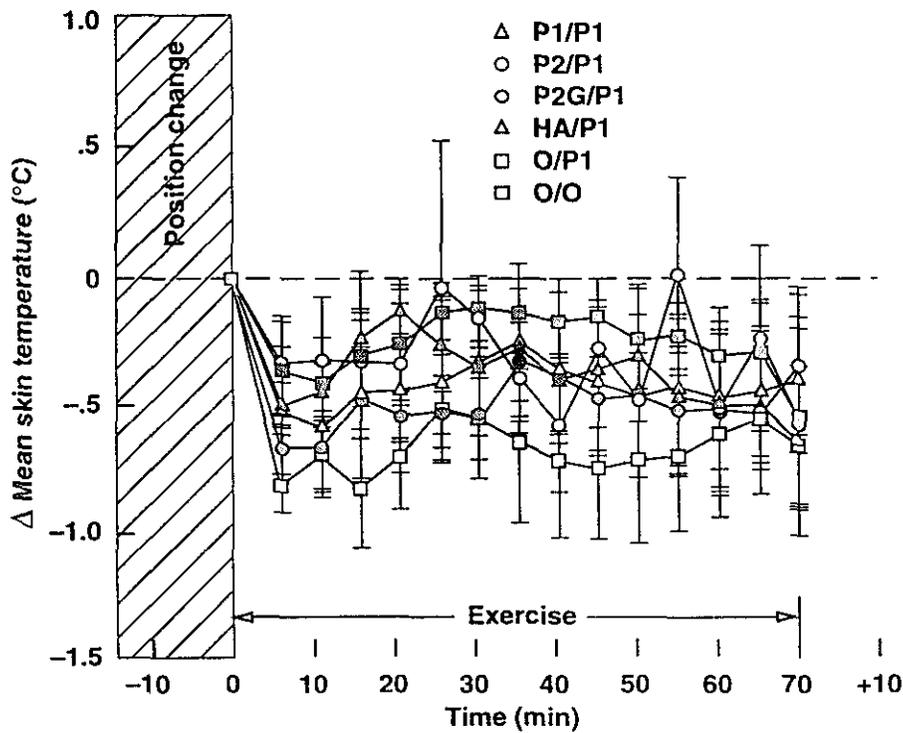
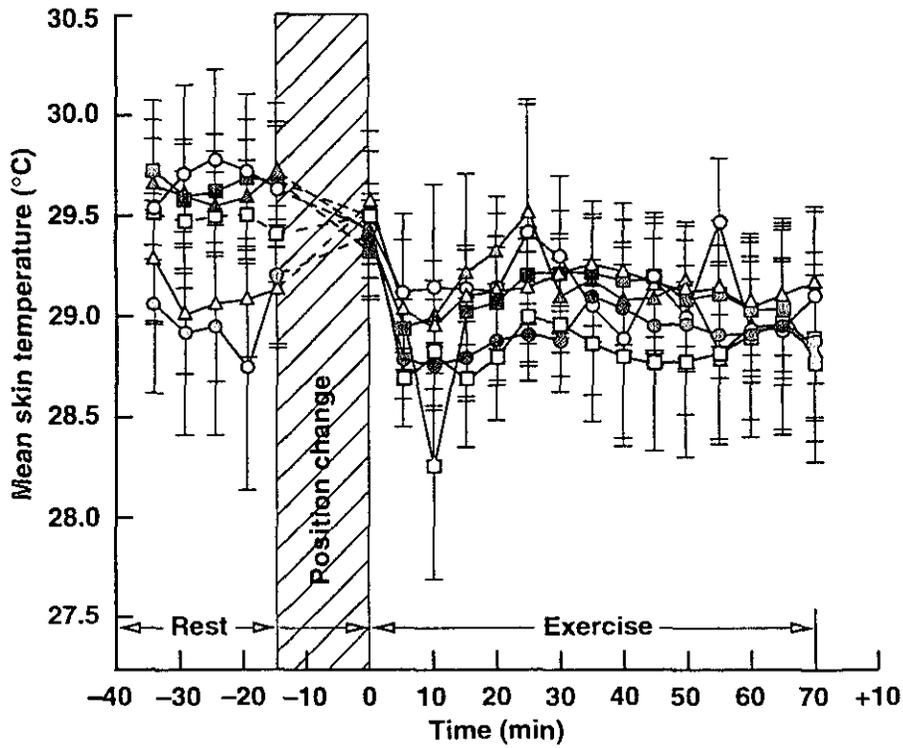


Figure 16. Mean ( $\pm$ SE) mean skin temperature at rest and during exercise for the six treatments.

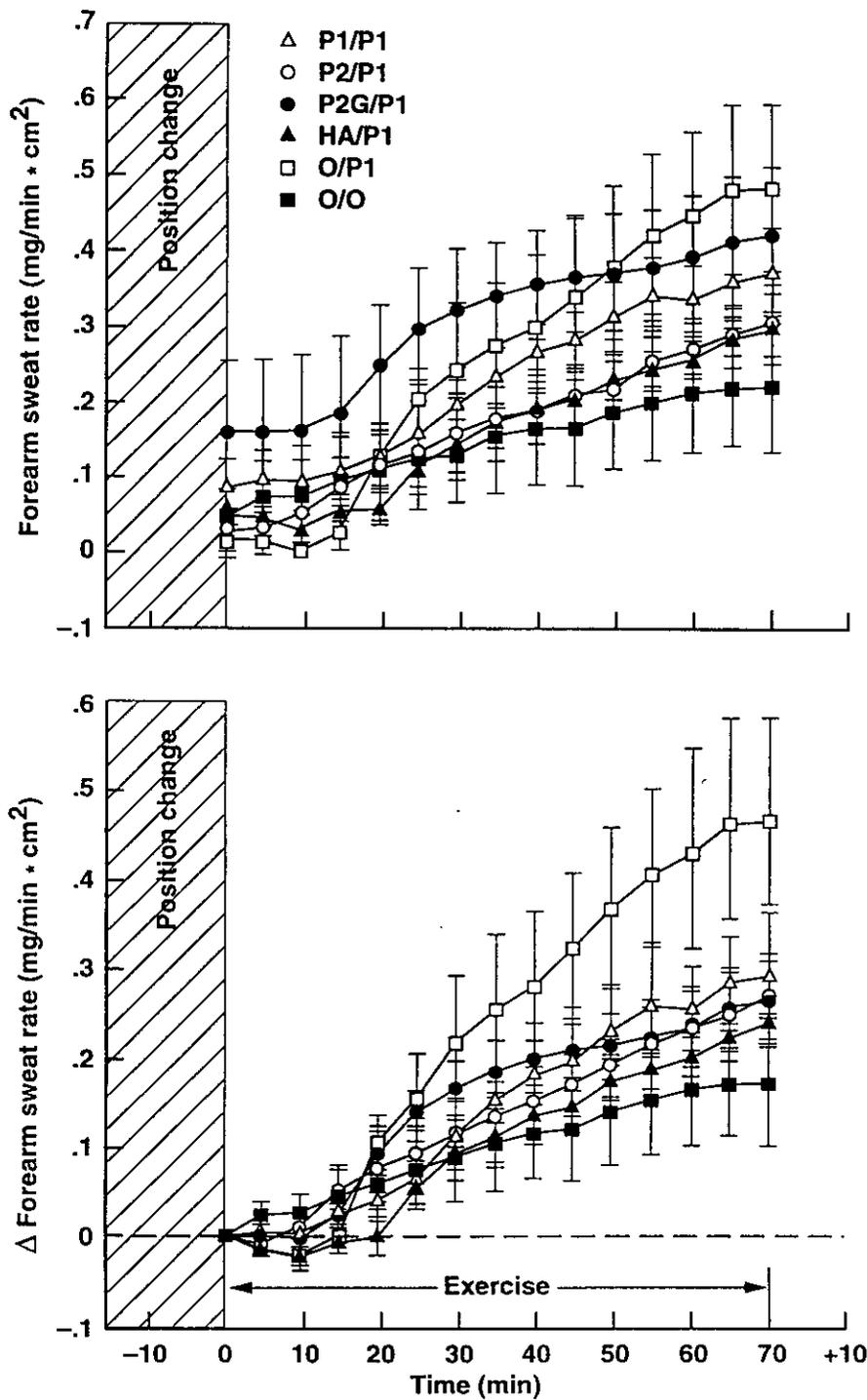


Figure 17. Mean ( $\pm$ SE) forearm sweat rate at rest and during exercise for the six treatments.

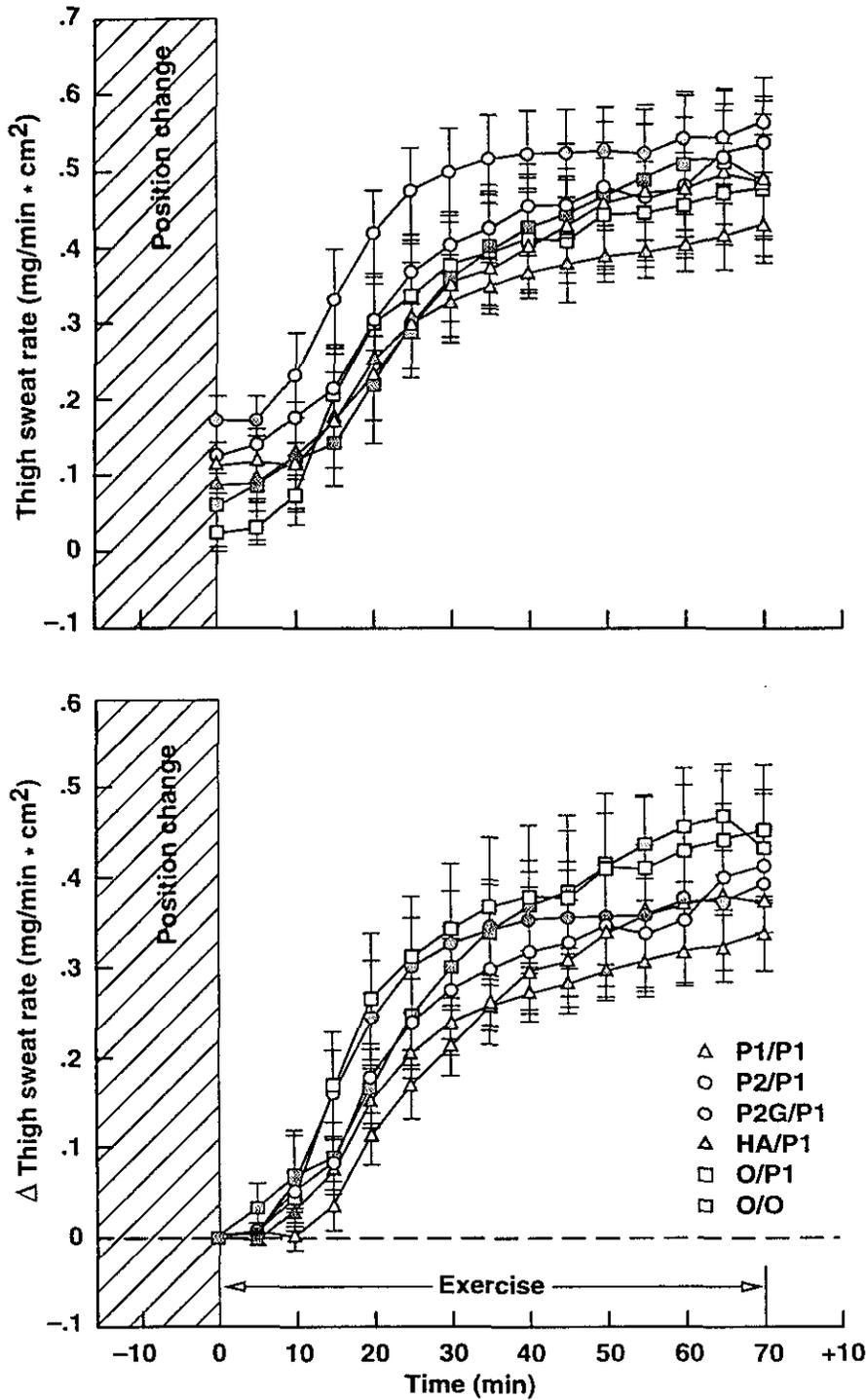


Figure 18. Mean ( $\pm$ SE) thigh sweat rate at rest and during exercise for the six treatments.

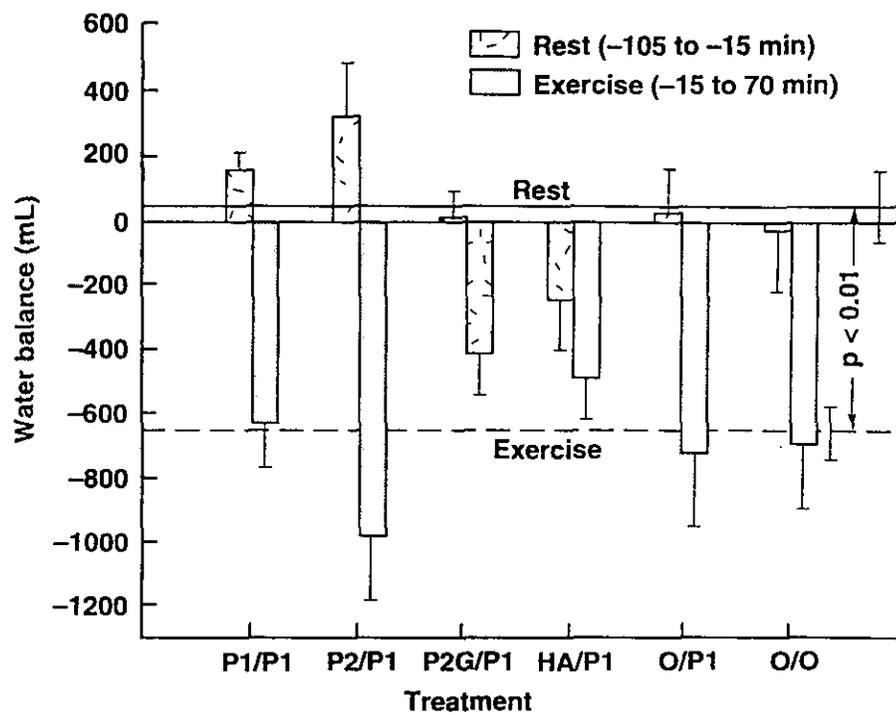


Figure 19. Mean ( $\pm$ SE) water balance at rest and during exercise for the six treatments.

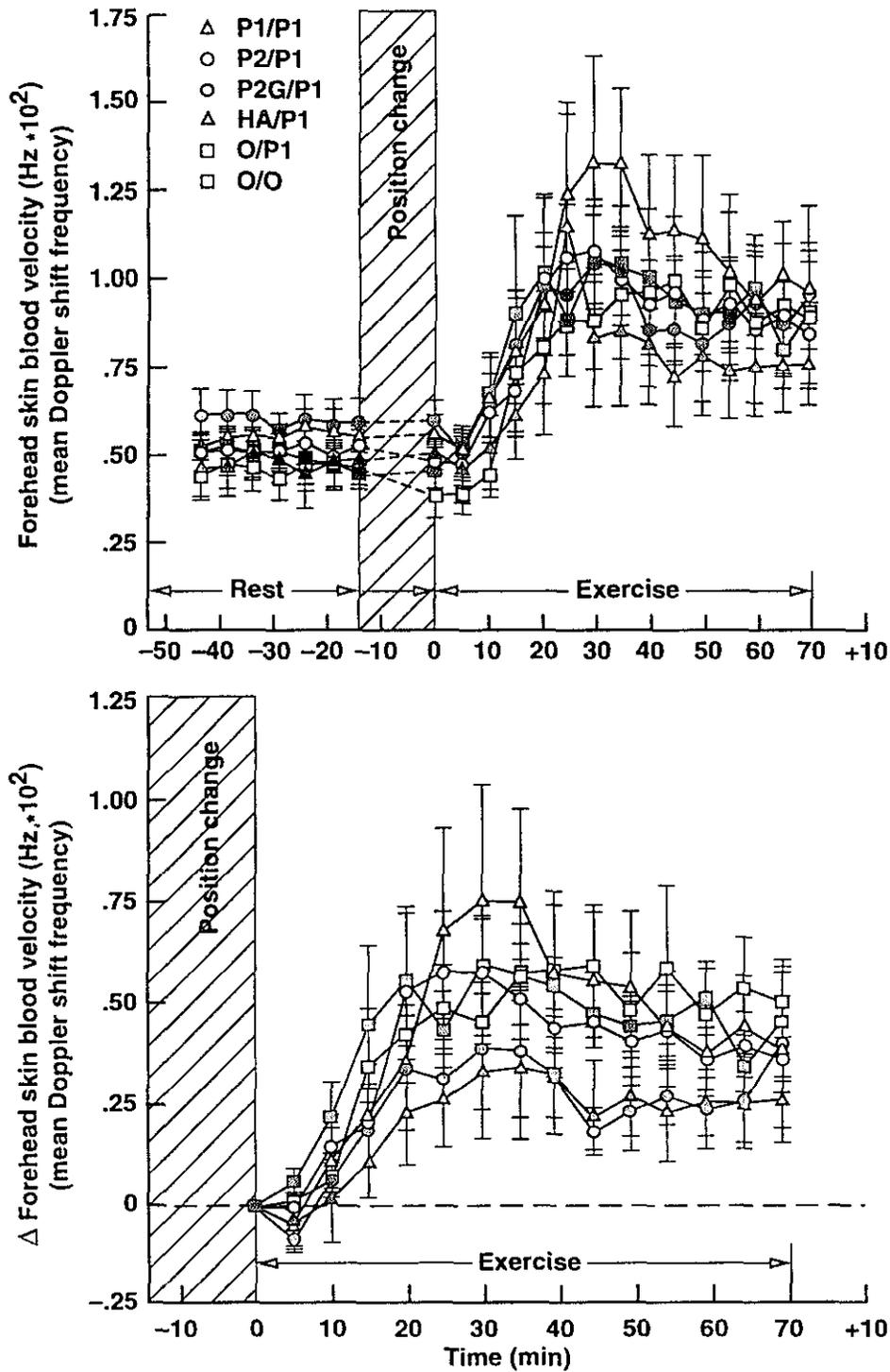


Figure 20. Mean ( $\pm$ SE) forehead skin blood velocity at rest and during exercise for the six treatments.

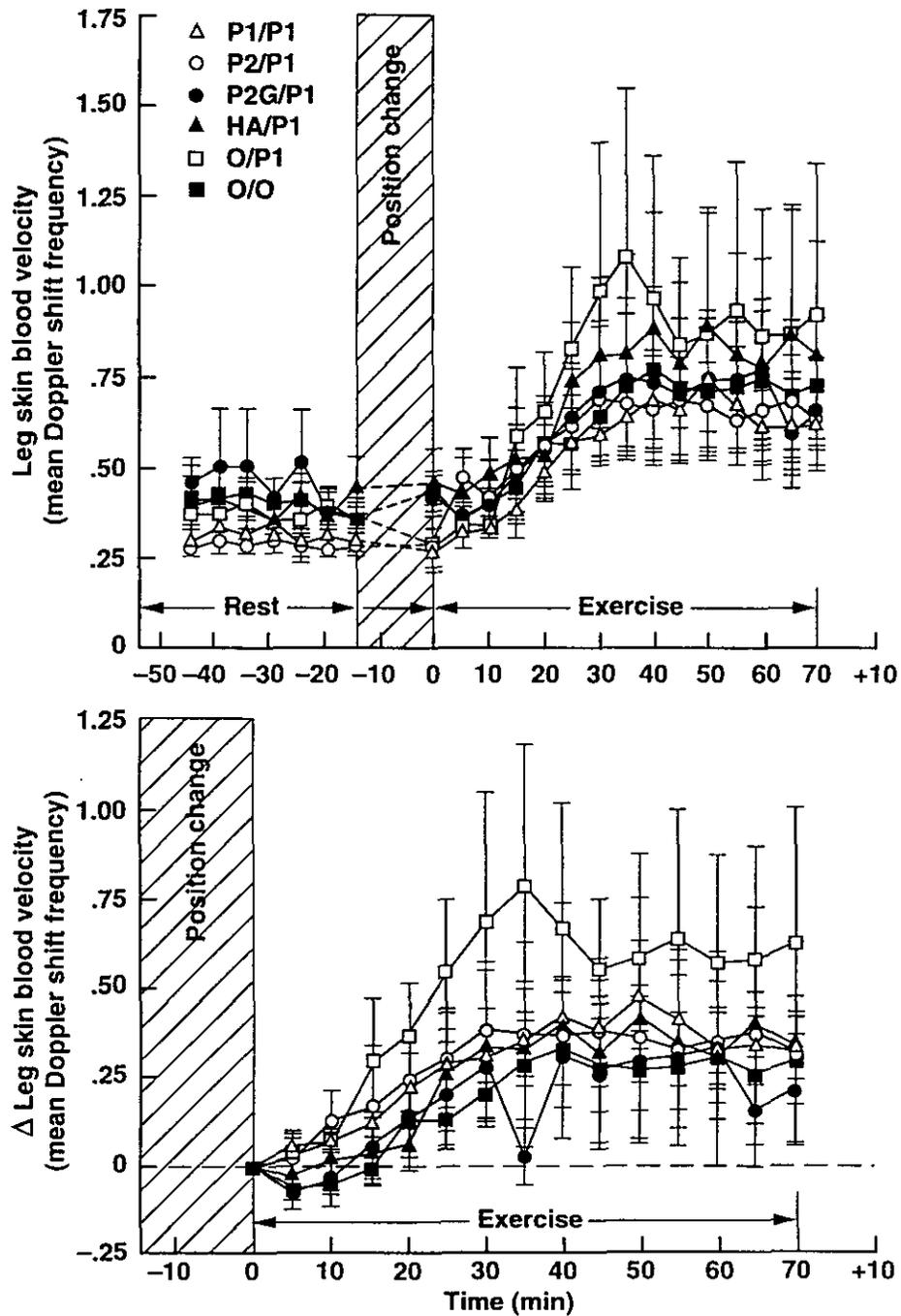


Figure 21. Mean ( $\pm$ SE) leg skin blood velocity at rest and during exercise for the six treatments.

Appendix 1. Mean metabolic data at rest and during exercise for the six treatments

|                                |           | P1P1  | P2P1  | P2GP1 | HAP1  | OP1   | 00    | Mean  |
|--------------------------------|-----------|-------|-------|-------|-------|-------|-------|-------|
| <b>Rest phase (-45 min)</b>    |           |       |       |       |       |       |       |       |
| $\dot{V}_{ESTPD}$              | $\bar{X}$ | 11.42 | 11.33 | 10.92 | 11.81 | 10.05 | 10.17 | 10.95 |
|                                | $\pm SD$  | 2.73  | 1.60  | 1.56  | 3.10  | 2.85  | 2.76  | 0.71  |
|                                | $\pm SE$  | 1.11  | 0.65  | 0.64  | 1.26  | 1.16  | 1.13  | 0.29  |
| $R_E$                          | $\bar{X}$ | 0.97  | 0.96  | 0.94  | 0.95  | 0.91  | 0.97  | 0.95  |
|                                | $\pm SD$  | 0.06  | 0.02  | 0.07  | 0.05  | 0.06  | 0.09  | 0.02  |
|                                | $\pm SE$  | 0.02  | 0.01  | 0.03  | 0.02  | 0.02  | 0.04  | 0.01  |
| $\dot{V}O_2$ (l/min)           | $\bar{X}$ | 0.40  | 0.39  | 0.40  | 0.40  | 0.36  | 0.35  | 0.38  |
|                                | $\pm SD$  | 0.08  | 0.05  | 0.03  | 0.08  | 0.07  | 0.08  | 0.02  |
|                                | $\pm SE$  | 0.03  | 0.02  | 0.01  | 0.03  | 0.03  | 0.03  | 0.01  |
| $\dot{V}O_2$ (mL/min · kg)     | $\bar{X}$ | 5.6   | 5.4   | 5.8   | 5.8   | 4.6   | 4.6   | 5.3   |
|                                | $\pm SD$  | 1.0   | 0.6   | 1.1   | 0.5   | 0.5   | 0.3   | 0.6   |
|                                | $\pm SE$  | 0.4   | 0.2   | 0.4   | 0.2   | 0.2   | 0.1   | 0.2   |
| <b>Exercise phase (35 min)</b> |           |       |       |       |       |       |       |       |
| $\dot{V}_{ESTPD}$              | $\bar{X}$ | 48.45 | 48.74 | 50.64 | 49.54 | 51.81 | 48.60 | 49.63 |
|                                | $\pm SD$  | 10.89 | 12.04 | 10.76 | 10.13 | 16.96 | 13.85 | 1.34  |
|                                | $\pm SE$  | 4.45  | 4.92  | 4.39  | 4.13  | 6.92  | 5.65  | 0.55  |
| $R_E$                          | $\bar{X}$ | 0.97  | 0.96  | 0.98  | 0.94  | 0.96  | 0.96  | 0.96  |
|                                | $\pm SD$  | 0.02  | 0.02  | 0.07  | 0.07  | 0.03  | 0.02  | 0.01  |
|                                | $\pm SE$  | 0.01  | 0.01  | 0.03  | 0.03  | 0.01  | 0.01  | 0.01  |
| $\dot{V}O_2$ (L/min)           | $\bar{X}$ | 2.01  | 2.09  | 2.08  | 2.12  | 2.03  | 2.02  | 2.06  |
|                                | $\pm SD$  | 0.32  | 0.35  | 0.28  | 0.38  | 0.38  | 0.38  | 0.04  |
|                                | $\pm SE$  | 0.13  | 0.14  | 0.11  | 0.15  | 0.15  | 0.15  | 0.02  |
| $\dot{V}O_2$ (mL/min · kg)     | $\bar{X}$ | 28.2  | 29.1  | 29.6  | 29.9  | 27.4  | 26.8  | 28.5  |
|                                | $\pm SD$  | 4.4   | 6.1   | 3.7   | 4.2   | 3.9   | 3.8   | 1.2   |
|                                | $\pm SE$  | 1.8   | 2.5   | 1.5   | 1.7   | 1.6   | 1.5   | 0.5   |
| <b>Exercise phase (65 min)</b> |           |       |       |       |       |       |       |       |
| $\dot{V}_{ESTPD}$              | $\bar{X}$ | 48.19 | 49.41 | 48.59 | 47.70 | 50.37 | 48.38 | 48.94 |
|                                | $\pm SD$  | 11.51 | 10.79 | 9.53  | 8.43  | 13.78 | 10.51 | 0.93  |
|                                | $\pm SE$  | 4.55  | 4.40  | 3.89  | 3.44  | 5.63  | 4.29  | 0.38  |
| $R_E$                          | $\bar{X}$ | 0.94  | 0.95  | 0.96  | 0.94  | 0.94  | 0.94  | 0.95  |
|                                | $\pm SD$  | 0.05  | 0.02  | 0.04  | 0.03  | 0.04  | 0.04  | 0.01  |
|                                | $\pm SE$  | 0.02  | 0.01  | 0.02  | 0.01  | 0.02  | 0.02  | 0.01  |

Appendix 1. Concluded

|                            |           |      |      |      |      |      |      |      |
|----------------------------|-----------|------|------|------|------|------|------|------|
| $\dot{V}O_2$ (L/min)       | $\bar{X}$ | 2.14 | 2.12 | 2.05 | 2.11 | 2.12 | 2.10 | 2.11 |
|                            | $\pm SD$  | 0.38 | 0.32 | 0.29 | 0.30 | 0.38 | 0.35 | 0.03 |
|                            | $\pm SE$  | 0.16 | 0.13 | 0.12 | 0.12 | 0.15 | 0.14 | 0.01 |
| $\dot{V}O_2$ (mL/min · kg) | $\bar{X}$ | 29.9 | 29.4 | 29.1 | 29.6 | 28.6 | 27.9 | 29.1 |
|                            | $\pm SD$  | 4.7  | 5.0  | 3.5  | 4.1  | 3.4  | 4.0  | 0.7  |
|                            | $\pm SE$  | 1.9  | 2.0  | 1.4  | 1.7  | 1.4  | 1.6  | 0.3  |

Appendix 2. Mean plasma citrate concentration at rest and during exercise for the six treatments

| Time (min) | Treatment | Rest phase |     | Exercise phase |     |     |
|------------|-----------|------------|-----|----------------|-----|-----|
|            |           | -105       | 0   | 10             | 30  | 70  |
| P1P1       | $\bar{X}$ | 1.7        | 2.3 | 2.4            | 1.9 | 2.4 |
|            | $\pm SD$  | 0.4        | 0.8 | 0.7            | 0.7 | 0.6 |
|            | $\pm SE$  | 0.2        | 0.3 | 0.3            | 0.3 | 0.2 |
| P2P1       | $\bar{X}$ | 1.8        | 2.5 | 2.7            | 2.4 | 2.6 |
|            | $\pm SD$  | 0.5        | 0.7 | 0.8            | 0.8 | 0.7 |
|            | $\pm SE$  | 0.2        | 0.3 | 0.3            | 0.3 | 0.3 |
| P2GP1      | $\bar{X}$ | 1.8        | 2.2 | 2.4            | 2.5 | 2.6 |
|            | $\pm SD$  | 0.8        | 0.6 | 0.7            | 0.7 | 0.6 |
|            | $\pm SE$  | 0.3        | 0.3 | 0.3            | 0.3 | 0.3 |
| HAP1       | $\bar{X}$ | 1.8        | 3.4 | 2.9            | 2.7 | 2.5 |
|            | $\pm SD$  | 0.5        | 0.6 | 0.6            | 0.5 | 0.6 |
|            | $\pm SE$  | 0.2        | 0.3 | 0.3            | 0.2 | 0.2 |
| OP1        | $\bar{X}$ | 2.2        | 1.8 | 2.0            | 1.8 | 2.3 |
|            | $\pm SD$  | 0.6        | 0.7 | 0.5            | 0.7 | 0.7 |
|            | $\pm SE$  | 0.3        | 0.3 | 0.2            | 0.3 | 0.3 |
| 00         | $\bar{X}$ | 1.9        | 1.7 | 1.9            | 1.9 | 2.1 |
|            | $\pm SD$  | 0.7        | 0.5 | 0.9            | 0.6 | 0.5 |
|            | $\pm SE$  | 0.3        | 0.2 | 0.4            | 0.2 | 0.2 |

Normal range = 1.7 – 3.0 mg/dL.

Appendix 3. Mean hemoglobin concentration and hematocrit at rest and during exercise for the six treatments

| Time (min) | Treatment | Rest phase        |      |      |      | Exercise phase |      |      |
|------------|-----------|-------------------|------|------|------|----------------|------|------|
|            |           | -105              | -30  | -25  | 0    | 10             | 30   | 70   |
|            |           | <b>Hemoglobin</b> |      |      |      |                |      |      |
|            | $\bar{X}$ | 16.3              | 16.4 | 16.3 | 16.4 | 17.0           | 17.0 | 16.5 |
| P1P1       | $\pm$ SD  | 0.5               | 1.0  | 0.6  | 0.8  | 0.7            | 0.6  | 0.6  |
|            | $\pm$ SE  | 0.2               | 0.4  | 0.2  | 0.3  | 0.3            | 0.3  | 0.2  |
|            | $\bar{X}$ | 16.6              | 16.4 | 16.4 | 16.6 | 17.0           | 17.1 | 17.0 |
| P2P1       | $\pm$ SD  | 0.4               | 0.7  | 0.6  | 0.6  | 0.6            | 0.4  | 0.7  |
|            | $\pm$ SE  | 0.2               | 0.3  | 0.2  | 0.3  | 0.2            | 0.2  | 0.3  |
|            | $\bar{X}$ | 16.6              | 16.6 | 16.5 | 16.4 | 17.0           | 17.0 | 16.8 |
| P2GP1      | $\pm$ SD  | 0.4               | 0.5  | 0.4  | 0.6  | 0.8            | 0.6  | 0.5  |
|            | $\pm$ SE  | 0.2               | 0.2  | 0.2  | 0.3  | 0.3            | 0.2  | 0.2  |
|            | $\bar{X}$ | 16.6              | 16.1 | 16.0 | 16.1 | 16.6           | 16.4 | 16.4 |
| HAP1       | $\pm$ SD  | 0.5               | 0.4  | 0.5  | 0.8  | 0.4            | 0.5  | 0.6  |
|            | $\pm$ SE  | 0.2               | 0.1  | 0.2  | 0.3  | 0.2            | 0.2  | 0.3  |
|            | $\bar{X}$ | 17.4              | 16.8 | 16.9 | 17.3 | 18.0           | 17.7 | 17.4 |
| OP1        | $\pm$ SD  | 1.1               | 1.1  | 1.1  | 1.0  | 1.2            | 1.4  | 1.4  |
|            | $\pm$ SE  | 0.4               | 0.4  | 0.4  | 0.4  | 0.5            | 0.6  | 0.6  |
|            | $\bar{X}$ | 16.6              | 16.6 | 16.4 | 16.8 | 17.5           | 17.3 | 17.2 |
| 00         | $\pm$ SD  | 0.3               | 0.7  | 0.5  | 0.9  | 0.5            | 0.8  | 0.9  |
|            | $\pm$ SE  | 0.1               | 0.3  | 0.2  | 0.4  | 0.2            | 0.3  | 0.4  |

Normal range = 13.6 – 17.2 g/dL.

| Time (min) | Treatment | <b>Hematocrit</b> |      |      |      |      |      |      |
|------------|-----------|-------------------|------|------|------|------|------|------|
|            |           | -105              | -30  | -25  | 0    | 10   | 30   | 70   |
|            | $\bar{X}$ | 45.3              | 45.9 | 45.6 | 45.8 | 47.4 | 46.8 | 46.0 |
| P1P1       | $\pm$ SD  | 1.5               | 1.8  | 1.7  | 2.5  | 2.2  | 1.7  | 2.1  |
|            | $\pm$ SE  | 0.6               | 0.7  | 0.7  | 1.0  | 0.9  | 0.7  | 0.9  |
|            | $\bar{X}$ | 46.7              | 46.2 | 46.0 | 46.5 | 47.8 | 47.5 | 46.5 |
| P2P1       | $\pm$ SD  | 2.3               | 1.9  | 1.9  | 1.9  | 1.7  | 1.2  | 1.0  |
|            | $\pm$ SE  | 0.9               | 0.8  | 0.8  | 0.8  | 0.7  | 0.5  | 0.4  |
|            | $\bar{X}$ | 46.8              | 46.6 | 46.2 | 46.7 | 48.1 | 47.3 | 47.0 |
| P2GP1      | $\pm$ SD  | 1.7               | 1.8  | 1.4  | 1.9  | 1.9  | 2.0  | 1.9  |
|            | $\pm$ SE  | 0.7               | 0.7  | 0.6  | 0.8  | 0.8  | 0.8  | 0.8  |
|            | $\bar{X}$ | 46.4              | 45.3 | 44.9 | 45.6 | 46.1 | 45.4 | 45.2 |
| HAP1       | $\pm$ SD  | 1.2               | 1.0  | 1.4  | 2.6  | 1.9  | 2.0  | 2.2  |
|            | $\pm$ SE  | 0.5               | 0.4  | 0.6  | 1.1  | 0.8  | 0.8  | 0.9  |
|            | $\bar{X}$ | 48.4              | 47.0 | 47.2 | 48.4 | 50.1 | 49.1 | 48.1 |
| OP1        | $\pm$ SD  | 2.1               | 2.2  | 1.9  | 2.0  | 2.4  | 2.9  | 2.8  |
|            | $\pm$ SE  | 0.8               | 0.9  | 0.8  | 0.8  | 1.0  | 1.2  | 1.1  |
|            | $\bar{X}$ | 46.6              | 46.1 | 46.4 | 47.1 | 49.0 | 47.9 | 47.3 |
| 00         | $\pm$ SD  | 0.8               | 1.4  | 1.5  | 1.8  | 1.6  | 1.7  | 2.1  |
|            | $\pm$ SE  | 0.3               | 0.6  | 0.6  | 0.7  | 0.6  | 0.7  | 0.9  |

Normal range = 39% – 49%.

Appendix 4. Mean red blood cell and white blood cell (leukocyte) concentrations at rest and during exercise for the six treatments

|            |           | Rest phase |      |      |      | Exercise phase |      |      |
|------------|-----------|------------|------|------|------|----------------|------|------|
|            |           | Red cells  |      |      |      |                |      |      |
| Time (min) |           | -105       | -30  | -25  | 0    | 10             | 30   | 70   |
| Treatment  |           |            |      |      |      |                |      |      |
|            | $\bar{X}$ | 5.33       | 5.26 | 5.23 | 5.24 | 5.48           | 5.43 | 5.38 |
| P1P1       | $\pm$ SD  | 0.30       | 0.25 | 0.24 | 0.24 | 0.26           | 0.20 | 0.28 |
|            | $\pm$ SE  | 0.12       | 0.10 | 0.10 | 0.10 | 0.11           | 0.08 | 0.11 |
|            | $\bar{X}$ | 5.36       | 5.30 | 5.27 | 5.33 | 5.50           | 5.54 | 5.46 |
| P2P1       | $\pm$ SD  | 0.31       | 0.20 | 0.25 | 0.22 | 0.20           | 0.20 | 0.20 |
|            | $\pm$ SE  | 0.13       | 0.08 | 0.10 | 0.09 | 0.08           | 0.08 | 0.08 |
|            | $\bar{X}$ | 5.34       | 5.32 | 5.28 | 5.33 | 5.53           | 5.49 | 5.47 |
| P2GP1      | $\pm$ SD  | 0.35       | 0.30 | 0.28 | 0.33 | 0.35           | 0.33 | 0.32 |
|            | $\pm$ SE  | 0.14       | 0.12 | 0.11 | 0.14 | 0.14           | 0.14 | 0.13 |
|            | $\bar{X}$ | 5.32       | 5.18 | 5.14 | 5.23 | 5.32           | 5.30 | 5.27 |
| HAP1       | $\pm$ SD  | 0.27       | 0.18 | 0.22 | 0.31 | 0.31           | 0.26 | 0.27 |
|            | $\pm$ SE  | 0.11       | 0.07 | 0.09 | 0.13 | 0.13           | 0.10 | 0.11 |
|            | $\bar{X}$ | 5.62       | 5.48 | 5.43 | 5.55 | 5.78           | 5.75 | 5.66 |
| OP1        | $\pm$ SD  | 0.27       | 0.30 | 0.23 | 0.23 | 0.30           | 0.38 | 0.38 |
|            | $\pm$ SE  | 0.11       | 0.12 | 0.09 | 0.09 | 0.12           | 0.16 | 0.16 |
|            | $\bar{X}$ | 5.39       | 5.34 | 5.36 | 5.42 | 5.71           | 5.64 | 5.55 |
| 00         | $\pm$ SD  | 0.15       | 0.17 | 0.19 | 0.15 | 0.21           | 0.19 | 0.28 |
|            | $\pm$ SE  | 0.06       | 0.07 | 0.08 | 0.06 | 0.09           | 0.08 | 0.11 |

Normal range =  $4.3-5.9 \times 10^6/\text{mm}^3$ .

|            |           | White cells |     |     |     |     |     |     |
|------------|-----------|-------------|-----|-----|-----|-----|-----|-----|
| Time (min) |           | -105        | -30 | -25 | 0   | 10  | 30  | 70  |
| Treatment  |           |             |     |     |     |     |     |     |
|            | $\bar{X}$ | 5.2         | 4.9 | 4.9 | 5.5 | 7.2 | 7.4 | 7.1 |
| P1P1       | $\pm$ SD  | 1.9         | 1.8 | 1.7 | 1.3 | 2.0 | 2.4 | 2.7 |
|            | $\pm$ SE  | 0.8         | 0.8 | 0.7 | 0.5 | 0.8 | 1.0 | 1.1 |
|            | $\bar{X}$ | 4.6         | 4.3 | 4.7 | 5.2 | 6.4 | 7.0 | 7.1 |
| P2P1       | $\pm$ SD  | 1.4         | 1.2 | 0.7 | 0.6 | 1.8 | 1.9 | 2.0 |
|            | $\pm$ SE  | 0.6         | 0.5 | 0.3 | 0.3 | 0.7 | 0.8 | 0.8 |
|            | $\bar{X}$ | 4.7         | 4.5 | 4.5 | 5.2 | 6.8 | 7.4 | 7.1 |
| P2GP1      | $\pm$ SD  | 0.9         | 1.0 | 1.1 | 1.4 | 1.8 | 2.2 | 2.1 |
|            | $\pm$ SE  | 0.4         | 0.4 | 0.4 | 0.6 | 0.7 | 0.9 | 0.9 |
|            | $\bar{X}$ | 4.9         | 4.6 | 4.7 | 5.5 | 6.2 | 6.6 | 6.6 |
| HAP1       | $\pm$ SD  | 1.0         | 0.9 | 0.8 | 1.8 | 1.3 | 1.5 | 1.5 |
|            | $\pm$ SE  | 0.4         | 0.4 | 0.3 | 0.8 | 0.5 | 0.6 | 0.6 |
|            | $\bar{X}$ | 5.6         | 5.2 | 5.1 | 5.5 | 7.6 | 8.0 | 7.9 |
| OP1        | $\pm$ SD  | 1.0         | 0.6 | 0.7 | 0.6 | 1.0 | 1.2 | 1.4 |
|            | $\pm$ SE  | 0.4         | 0.3 | 0.3 | 0.3 | 0.4 | 0.5 | 0.6 |
|            | $\bar{X}$ | 4.6         | 4.7 | 4.6 | 5.0 | 7.0 | 7.0 | 7.5 |
| 00         | $\pm$ SD  | 1.1         | 1.3 | 1.3 | 1.4 | 2.1 | 2.4 | 3.4 |
|            | $\pm$ SE  | 0.5         | 0.5 | 0.5 | 0.6 | 0.8 | 1.0 | 1.4 |

Normal range =  $3.2-9.8 \times 10^3/\text{mm}^3$ .

Appendix 5. Mean platelet (thrombocyte) concentration at rest and during exercise for the six treatments

| Time (min) | Treatment | Rest phase |     |     |     | Exercise phase |     |     |
|------------|-----------|------------|-----|-----|-----|----------------|-----|-----|
|            |           | -105       | -30 | -25 | 0   | 10             | 30  | 70  |
|            | $\bar{X}$ | 210        | 210 | 204 | 206 | 226            | 250 | 260 |
| P1P1       | $\pm$ SD  | 33         | 44  | 38  | 34  | 43             | 49  | 60  |
|            | $\pm$ SE  | 13         | 18  | 16  | 14  | 18             | 20  | 24  |
|            | $\bar{X}$ | 210        | 212 | 206 | 217 | 240            | 259 | 246 |
| P2P1       | $\pm$ SD  | 50         | 58  | 53  | 64  | 59             | 54  | 88  |
|            | $\pm$ SE  | 20         | 24  | 22  | 26  | 24             | 22  | 36  |
|            | $\bar{X}$ | 211        | 216 | 212 | 216 | 244            | 248 | 270 |
| P2GP1      | $\pm$ SD  | 46         | 47  | 50  | 47  | 47             | 57  | 60  |
|            | $\pm$ SE  | 19         | 19  | 20  | 19  | 19             | 23  | 25  |
|            | $\bar{X}$ | 218        | 210 | 209 | 204 | 226            | 224 | 240 |
| HAP1       | $\pm$ SD  | 47         | 42  | 40  | 23  | 50             | 60  | 51  |
|            | $\pm$ SE  | 19         | 17  | 16  | 10  | 20             | 25  | 21  |
|            | $\bar{X}$ | 215        | 225 | 220 | 220 | 239            | 248 | 279 |
| OP1        | $\pm$ SD  | 32         | 33  | 48  | 53  | 47             | 54  | 40  |
|            | $\pm$ SE  | 13         | 14  | 19  | 22  | 19             | 22  | 16  |
|            | $\bar{X}$ | 202        | 206 | 198 | 206 | 221            | 232 | 240 |
| 00         | $\pm$ SD  | 43         | 41  | 43  | 41  | 33             | 35  | 38  |
|            | $\pm$ SE  | 18         | 17  | 18  | 17  | 13             | 14  | 16  |

Normal range =  $150 - 450 \times 10^3/\text{mm}^3$ .

Appendix 6. Individual resting hematocrit and plasma and blood volumes for the six treatments

| Subject  | Date<br>(treatment) | Corrected absorbance<br>pre-dye/post-dye | Dye injected,<br>mL | Hct,<br>% | Plasma volume,<br>mL | Blood volume,<br>mL |
|----------|---------------------|------------------------------------------|---------------------|-----------|----------------------|---------------------|
| CAL      | 8/19/93             | 0.005                                    |                     |           |                      |                     |
|          | (00)                | 0.037                                    | 2.6123              | 46.3      | 3240                 | 5598                |
|          | 8/26/93             | 0.011                                    |                     |           |                      |                     |
|          | (P1P1)              | 0.051                                    | 2.5329              | 45.4      | 2536                 | 4321                |
|          | 9/2/93              | 0.008                                    |                     |           |                      |                     |
|          | (0P1)               | 0.050                                    | 2.7194              | 45.5      | 2562                 | 4372                |
|          | 9/16/93             | 0.010                                    |                     |           |                      |                     |
|          | (P2GP1)             | 0.052                                    | 2.5604              | 48.6      | 2471                 | 4430                |
|          | 9/23/93             | 0.020                                    |                     |           |                      |                     |
|          | (HAP1)              | 0.050                                    | 2.6036              | 46.0      | 3539                 | 6087                |
|          | 9/27/93             | 0.024                                    |                     |           |                      |                     |
|          | (P2P1)              | 0.052                                    | 2.4783              | 46.8      | 3609                 | 6286                |
|          | $\bar{X}$           |                                          |                     | 2.5845    | 46.4                 | 2993                |
| $\pm$ SD |                     |                                          | 0.0823              | 1.2       | 530                  | 914                 |
| $\pm$ SE |                     |                                          | 0.0336              | 0.5       | 216                  | 373                 |
| DUW      | 8/18/93             | 0.005                                    |                     |           |                      |                     |
|          | (0P1)               | 0.031                                    | 2.6860              | 48.6      | 4112                 | 7373                |
|          | 8/25/93             | 0.009                                    |                     |           |                      |                     |
|          | (00)                | 0.038                                    | 2.5103              | 46.4      | 3467                 | 6000                |
|          | 9/1/93              | 0.008                                    |                     |           |                      |                     |
|          | (HAP1)              | 0.034                                    | 2.5974              | 46.7      | 3880                 | 6747                |
|          | 9/8/93              | 0.008                                    |                     |           |                      |                     |
|          | (P1P1)              | 0.034                                    | 2.5701              | 46.8      | 3911                 | 6812                |
|          | 9/15/93             | 0.016                                    |                     |           |                      |                     |
|          | (P2P1)              | 0.040                                    | 2.5502              | 45.7      | 4178                 | 7153                |
|          | 9/22/93             | 0.014                                    |                     |           |                      |                     |
|          | (P2GP1)             | 0.037                                    | 2.5804              | 47.0      | 4575                 | 7994                |
|          | $\bar{X}$           |                                          |                     | 2.5824    | 46.9                 | 4020                |
| $\pm$ SD |                     |                                          | 0.0589              | 1.0       | 368                  | 671                 |
| $\pm$ SE |                     |                                          | 0.0240              | 0.4       | 150                  | 274                 |
| GUF      | 8/19/93             | 0.004                                    |                     |           |                      |                     |
|          | (00)                | 0.044                                    | 2.5716              | 49.2      | 2551                 | 4620                |
|          | 8/26/93             | 0.013                                    |                     |           |                      |                     |
|          | (P1P1)              | 0.062                                    | 2.6174              | 48.5      | 2139                 | 3829                |
|          | 9/2/93              | 0.015                                    |                     |           |                      |                     |
|          | (0P1)               | 0.055                                    | 2.6029              | 45.8      | 2527                 | 4333                |
|          | 9/9/93              | 0.015                                    |                     |           |                      |                     |
|          | (P2P1)              | 0.065                                    | 2.6039              | 48.9      | 2060                 | 3712                |
|          | 9/16/93             | 0.031                                    |                     |           |                      |                     |
|          | (P2GP1)             | 0.062                                    | 2.4945              | 46.4      | 3164                 | 5476                |
|          | 9/23/93             | 0.023                                    |                     |           |                      |                     |
| (HAP1)   | 0.065               | 2.5431                                   | 45.8                | 2454      | 4208                 |                     |

Appendix 6. Continued

|         |           |        |        |      |      |      |
|---------|-----------|--------|--------|------|------|------|
|         | $\bar{X}$ |        | 2.5732 | 47.4 | 2482 | 4363 |
|         | $\pm$ SD  |        | 0.0475 | 1.6  | 392  | 639  |
|         | $\pm$ SE  |        | 0.0194 | 0.6  | 160  | 261  |
| PAU     | 8/18/93   | 0.005  |        |      |      |      |
|         | (0P1)     | 0.041  | 2.6221 | 50.2 | 2899 | 5338 |
|         | 8/25/93   | 0.010  |        |      |      |      |
|         | (00)      | 0.046  | 2.5099 | 44.7 | 2792 | 4707 |
|         | 9/1/93    | 0.010  |        |      |      |      |
|         | (HAP1)    | 0.044  | 2.5532 | 43.6 | 2916 | 4834 |
|         | 9/8/93    | 0.012  |        |      |      |      |
|         | (P1P1)    | 0.047  | 2.6284 | 44.5 | 2971 | 4993 |
|         | 9/15/93   | 0.020  |        |      |      |      |
|         | (P2P1)    | 0.050  | 2.5706 | 43.8 | 3369 | 5602 |
|         | 9/22/93   | 0.014  |        |      |      |      |
| (P2GP1) | 0.054     | 2.5799 | 45.0   | 2614 | 4427 |      |
|         | $\bar{X}$ |        | 2.5744 | 45.3 | 2927 | 4984 |
|         | $\pm$ SD  |        | 0.0443 | 2.5  | 251  | 428  |
|         | $\pm$ SE  |        | 0.0181 | 1.0  | 102  | 175  |
| PED     | 8/17/93   | 0.003  |        |      |      |      |
|         | (P2P1)    | 0.034  | 2.5038 | 46.7 | 3215 | 5591 |
|         | 8/24/93   | 0.012  |        |      |      |      |
|         | (0P1)     | 0.044  | 2.5538 | 47.5 | 3167 | 5578 |
|         | 8/31/93   | 0.013  |        |      |      |      |
|         | (P2GP1)   | 0.045  | 2.6018 | 45.1 | 3158 | 5355 |
|         | 9/7/93    | 0.015  |        |      |      |      |
|         | (00)      | 0.055  | 2.5890 | 46.4 | 2561 | 4432 |
|         | 9/14/93   | 0.026  |        |      |      |      |
|         | (HAP1)    | 0.052  | 2.5791 | 43.5 | 3900 | 6456 |
|         | 9/21/93   | 0.019  |        |      |      |      |
| (P1P1)  | 0.058     | 2.6069 | 43.7   | 2709 | 4498 |      |
|         | $\bar{X}$ |        | 2.5724 | 45.5 | 3118 | 5318 |
|         | $\pm$ SD  |        | 0.0385 | 1.6  | 470  | 761  |
|         | $\pm$ SE  |        | 0.0157 | 0.7  | 192  | 311  |
| REA     | 8/16/93   | 0.004  |        |      |      |      |
|         | (P1P1)    | 0.041  | 2.5370 | 44.9 | 2729 | 4615 |
|         | 8/24/93   | 0.009  |        |      |      |      |
|         | (HAP1)    | 0.040  | 2.5617 | 45.6 | 3279 | 5605 |
|         | 8/30/93   | 0.009  |        |      |      |      |
|         | (P2P1)    | 0.040  | 2.5069 | 44.3 | 3140 | 5262 |
|         | 9/13/93   | 0.015  |        |      |      |      |
|         | (P2GP1)   | 0.044  | 2.5124 | 45.4 | 3406 | 5805 |
|         | 9/20/93   | 0.012  |        |      |      |      |
|         | (0P1)     | 0.050  | 2.5330 | 45.7 | 2702 | 4626 |
|         | 9/27/93   | 0.022  |        |      |      |      |
| (00)    | 0.046     | 2.4971 | 45.6   | 4243 | 7252 |      |

Appendix 6. Concluded

|           |        |      |      |      |
|-----------|--------|------|------|------|
| $\bar{X}$ | 2.5247 | 45.2 | 3250 | 5528 |
| $\pm$ SD  | 0.0237 | 0.6  | 565  | 977  |
| $\pm$ SE  | 0.0097 | 0.2  | 231  | 399  |

From -35 to -25 min.

Appendix 7. Individual blood and plasma variables at rest and during exercise for the six treatments

| Time, min | Treatment | White blood cells<br>3.4-10.0 × 1000 | Red blood cells<br>4.4-5.9 M/UL | Hemoglobin<br>13.5-17.5 gm/dL | Hematocrit<br>41-53% | Platelets<br>130-400 × 1000 | Sodium, plasma<br>135-148 mEq/L | Potassium, plasma<br>3.6-5.0 mEq/L | Glucose, plasma<br>64-115 mg/dL | Glycerol, plasma<br>3-17 mg/dL <sup>b</sup> | Citrate, plasma<br>1.7-3.0 mg/dL |  |
|-----------|-----------|--------------------------------------|---------------------------------|-------------------------------|----------------------|-----------------------------|---------------------------------|------------------------------------|---------------------------------|---------------------------------------------|----------------------------------|--|
|           |           | Subject CAL                          |                                 |                               |                      |                             |                                 |                                    |                                 |                                             |                                  |  |
|           | PIP1      | 5                                    | 5.71                            | 15.9                          | 48.8                 | 191                         | 146.9                           | 4.5                                | 90                              | 4                                           | 1.6 <sup>a</sup>                 |  |
|           | P2P1      | 2.4 <sup>a</sup>                     | 5.81                            | 16.4                          | 49.3                 | 160                         | 146.4                           | 4.5                                | 144 <sup>a</sup>                | 16                                          | 2.7                              |  |
| -105      | P2GP1     | 5.1                                  | 5.83                            | 16.6                          | 49.1                 | 195                         | 146.9                           | 4.2                                | 134 <sup>a</sup>                | 6                                           | 3.3 <sup>a</sup>                 |  |
|           | HAP1      | 5.1                                  | 5.7                             | 16.2                          | 49.1                 | 167                         | 146.5                           | 4.8                                | 109                             | 8                                           | 2.5                              |  |
|           | OP1       | 6.5                                  | 5.75                            | 16.4                          | 49.1                 | 210                         | 147.8                           | 4.3                                | 105                             | 12                                          | 2.9                              |  |
|           | 00        | 4.6                                  | 5.59                            | 15.7                          | 48                   | 162                         | 166.1 <sup>a</sup>              | 4.3                                | 91                              | 8                                           | 1.7                              |  |
|           | PIP1      | 4.5                                  | 5.51                            | 15.6                          | 47                   | 175                         | 146.6                           | 4.3                                | 78                              | 3                                           | -                                |  |
|           | P2P1      | 2.1 <sup>a</sup>                     | 5.54                            | 15.8                          | 47                   | 162                         | 147.2                           | 4.2                                | 132 <sup>a</sup>                | 9                                           | -                                |  |
| -35       | P2GP1     | 4.9                                  | 5.78                            | 16.5                          | 49.3                 | 193                         | 146.9                           | 4                                  | 135 <sup>a</sup>                | 105 <sup>a</sup>                            | -                                |  |
|           | HAP1      | 5.8                                  | 5.44                            | 15.4                          | 46.5                 | 172                         | 146.1                           | 4.7                                | 74                              | 6                                           | -                                |  |
|           | OP1       | 5.4                                  | 5.29                            | 15.2                          | 45.1                 | 202                         | 145.6                           | 4.1                                | 132 <sup>a</sup>                | 8                                           | -                                |  |
|           | 00        | 4.8                                  | 5.41                            | 15.4                          | 46.4                 | 167                         | 146.8                           | 4.4                                | 74                              | 5                                           | -                                |  |
|           | PIP1      | 4.6                                  | 5.35                            | 15.1                          | 45.8                 | 165                         | 146.8                           | 4.1                                | 74                              | 8                                           | -                                |  |
|           | P2P1      | 2.2 <sup>a</sup>                     | 5.61                            | 15.8                          | 47.8                 | 154                         | 147                             | 4.1                                | 128 <sup>a</sup>                | 17                                          | -                                |  |
| -25       | P2GP1     | 5                                    | 5.7                             | 16.3                          | 48.3                 | 177                         | 147.6                           | 3.8                                | 99                              | 102 <sup>a</sup>                            | -                                |  |
|           | HAP1      | 5.6                                  | 5.44                            | 15.4                          | 46.2                 | 165                         | 145.7                           | 4.7                                | 75                              | 9                                           | -                                |  |
|           | OP1       | 5.5                                  | 5.35                            | 15.2                          | 45.7                 | 184                         | 146                             | 4                                  | 105                             | 12                                          | -                                |  |
|           | 00        | 5.5                                  | 5.54                            | 15.7                          | 47.9                 | 163                         | 147                             | 4.3                                | 61 <sup>a</sup>                 | 21 <sup>a</sup>                             | -                                |  |
|           | PIP1      | 4.9                                  | 5.47                            | 15.5                          | 46.7                 | 180                         | 146.5                           | 4                                  | 52 <sup>a</sup>                 | 9                                           | 2.8                              |  |
|           | P2P1      | 2.5 <sup>a</sup>                     | 5.66                            | 15.7                          | 48.1                 | 165                         | 146.7                           | 4.5                                | 122 <sup>a</sup>                | 9                                           | 3.1 <sup>a</sup>                 |  |
| 0         | P2GP1     | 6.4                                  | 5.9                             | 16.8                          | 50.6                 | 200                         | 148.9 <sup>a</sup>              | 4                                  | 54 <sup>a</sup>                 | 96 <sup>a</sup>                             | 2.9                              |  |
|           | HAP1      | 6.3                                  | 5.67                            | 16                            | 48.5                 | 173                         | 145.9                           | 4.7                                | 67                              | 8                                           | 3.9 <sup>a</sup>                 |  |
|           | OP1       | 5.7                                  | 5.56                            | 15.9                          | 47.4                 | 198                         | 148.3 <sup>a</sup>              | 3.8                                | 72                              | 11                                          | 2.2                              |  |
|           | 00        | 5.2                                  | 5.37                            | 15.2                          | 45.7                 | 163                         | 155.1 <sup>a</sup>              | 4.5                                | 77                              | 7                                           | 2.2                              |  |

Appendix 7. Continued

|                    |       |     |                   |      |      |     |                    |                  |                  |                 |                  |
|--------------------|-------|-----|-------------------|------|------|-----|--------------------|------------------|------------------|-----------------|------------------|
|                    | PIPI  | 6.9 | 5.71              | 16.3 | 49.2 | 197 | 147.6              | 4.5              | 44 <sup>a</sup>  | 8               | 2.9              |
|                    | P2PI  | 3.4 | 5.82              | 16.5 | 49.6 | 181 | 148.9 <sup>a</sup> | 4.4              | 69               | 13              | 3.7 <sup>a</sup> |
| 10                 | P2GPI | 8.5 | 6.11 <sup>a</sup> | 17.5 | 52.5 | 227 | 149.8 <sup>a</sup> | 4.5              | 48 <sup>a</sup>  | 96 <sup>a</sup> | 2.8              |
|                    | HAPI  | 7.9 | 5.84              | 16.7 | 50.2 | 174 | 147.1              | 5.1 <sup>a</sup> | 80               | 8               | 3.5 <sup>a</sup> |
|                    | OP1   | 7.8 | 5.76              | 16.5 | 49.3 | 233 | 148.9 <sup>a</sup> | 4.1              | 64               | 29 <sup>a</sup> | 2.5              |
|                    | 00    | 7.5 | 5.96 <sup>a</sup> | 16.9 | 51   | 184 | 147                | 5.2 <sup>a</sup> | 70               | 8               | 1.3 <sup>a</sup> |
|                    | PIPI  | 7.5 | 5.53              | 15.7 | 47.8 | 219 | 147.2              | 5.1 <sup>a</sup> | 69               | 7               | 0.4 <sup>a</sup> |
|                    | P2PI  | 3.8 | 5.89              | 16.4 | 50.2 | 205 | 149.1 <sup>a</sup> | 4.9              | 74               | 11              | 3.4 <sup>a</sup> |
| 30                 | P2GPI | 9.2 | 5.98 <sup>a</sup> | 17.1 | 50.9 | 247 | 149.9 <sup>a</sup> | 4.6              | 53 <sup>a</sup>  | 95 <sup>a</sup> | 3.2 <sup>a</sup> |
|                    | HAPI  | 7.2 | 5.61              | 15.9 | 48   | 150 | 141.2              | 4.9              | 99               | 6               | 3.4 <sup>a</sup> |
|                    | OP1   | 8.5 | 5.74              | 16.3 | 48.8 | 248 | 149.1 <sup>a</sup> | 4.7              | 83               | 30 <sup>a</sup> | 2.2              |
|                    | 00    | 7.1 | 5.64              | 16   | 47.7 | 199 | 148.1              | 5                | 65               | 7               | 2.6              |
|                    | PIPI  | 8.4 | 5.54              | 15.8 | 47.5 | 238 | 147.6              | 5.1 <sup>a</sup> | 84               | 11              | 3                |
|                    | P2PI  | 3.8 | 5.8               | 16.4 | 49.4 | 210 | 148                | 4.9              | 102              | 8               | 3.5 <sup>a</sup> |
| 70                 | P2GPI | 9.5 | 5.91 <sup>a</sup> | 16.9 | 50.7 | 253 | 149.3              | 5                | 75               | 64 <sup>a</sup> | 3.2 <sup>a</sup> |
|                    | HAPI  | 7.5 | 5.63              | 15.9 | 48.4 | 175 | 146.5              | 5.1 <sup>a</sup> | 88               | 8               | 3.6 <sup>a</sup> |
|                    | OP1   | 8.8 | 5.63              | 16   | 47.8 | 270 | 147.8              | 5                | 93               | 15              | 2.8              |
|                    | 00    | 9.6 | 5.46              | 15.6 | 46.6 | 216 | 159.8 <sup>a</sup> | 5                | 91               | 8               | 2.5              |
| <b>Subject DUW</b> |       |     |                   |      |      |     |                    |                  |                  |                 |                  |
|                    | PIPI  | 5.5 | 5.3               | 16.5 | 48.2 | 164 | 145.2              | 4.8              | 105              | 4               | 2.2              |
|                    | P2PI  | 5.3 | 5.01              | 15.6 | 46   | 161 | 144.8              | 4.9              | 129 <sup>a</sup> | 4               | 1.6 <sup>a</sup> |
| -105               | P2GPI | 5.5 | 5.16              | 15.9 | 47.5 | 169 | 144.2              | 4.6              | 129 <sup>a</sup> | 5               | 1.6 <sup>a</sup> |
|                    | HAPI  | 5.3 | 5.25              | 16.3 | 48   | 178 | 144.3              | 4.7              | 124 <sup>a</sup> | 6               | 2.2              |
|                    | OP1   | 6.6 | 5.71              | 17.2 | 52.7 | 195 | 146.1              | 4.6              | 124 <sup>a</sup> | 8               | 2.2              |
|                    | 00    | 6.2 | 5.36              | 16.2 | 48.9 | 171 | 143.6              | 5.3 <sup>a</sup> | 134 <sup>a</sup> | 11              | 2.3              |
|                    | PIPI  | 6.7 | 5.25              | 16.2 | 48.2 | 158 | 146.1              | 4.5              | 72               | 4               | -                |
|                    | P2PI  | 5.7 | 5.18              | 16.1 | 47.6 | 164 | 146.2              | 4.5              | 79               | 4               | -                |
| -35                | P2GPI | 5.5 | 5.16              | 16   | 47.5 | 173 | 145.9              | 4.1              | 91               | 5               | -                |
|                    | HAPI  | 4.8 | 5.15              | 16.2 | 47.4 | 176 | 145.5              | 4.6              | 65               | 3               | -                |
|                    | OP1   | 6   | 5.7               | 17.1 | 52.9 | 190 | 145.6              | 4.7              | 80               | 6               | -                |
|                    | 00    | 6.1 | 5.28              | 16.1 | 48.6 | 166 | 145.7              | 4.9              | 99               | 5               | -                |

Appendix 7. Continued

|     |       |                   |                   |                   |                   |     |                    |                  |                 |                 |                  |
|-----|-------|-------------------|-------------------|-------------------|-------------------|-----|--------------------|------------------|-----------------|-----------------|------------------|
|     | PIP1  | 6.5               | 5.13              | 16.1              | 46.9              | 168 | 145.6              | 4.7              | 71              | 7               | -                |
|     | P2P1  | 5.6               | 4.99              | 15.7              | 45.8              | 161 | 146.2              | 4.1              | 87              | 5               | -                |
| -25 | P2GPI | 5.9               | 5.21              | 16                | 48.2              | 163 | 145.9              | 4.1              | 84              | 6               | -                |
|     | HAPI  | 5                 | 5.14              | 16                | 47.4              | 175 | 145.8              | 4.3              | 49 <sup>a</sup> | 8               | -                |
|     | OP1   | 5.7               | 5.51              | 17                | 50.5              | 181 | 145.2              | 4.4              | 80              | 8               | -                |
|     | 00    | 6                 | 5.26              | 16.3              | 48.3              | 159 | 145.2              | 4.5              | 88              | 12              | -                |
|     | PIP1  | 6.9               | 5.24              | 16.2              | 48.1              | 169 | 145.9              | 4.7              | 60 <sup>a</sup> | 6               | 2.1              |
|     | P2P1  | 5.8               | 5.2               | 16.3              | 47.7              | 163 | 146.9              | 4.2              | 59 <sup>a</sup> | 4               | 2.4              |
| 0   | P2GPI | 7                 | 5.31              | 16.3              | 48.8              | 172 | 146.6              | 4.3              | 52 <sup>a</sup> | 6               | 2.3              |
|     | HAPI  | 8.6               | 5.42              | 17                | 49.4              | 184 | 145.1              | 4.9              | 49 <sup>a</sup> | 8               | 3.4 <sup>a</sup> |
|     | OP1   | 6                 | 5.67              | 17.6 <sup>a</sup> | 52.6              | 180 | 146.3              | 5.1              | 79              | 7               | 1.1 <sup>a</sup> |
|     | 00    | 6.9               | 5.43              | 16.7              | 50.1              | 175 | 145.3              | 4.5              | 70              | 12              | 1.9              |
|     | PIP1  | 9.9               | 5.49              | 17.1              | 50.4              | 194 | 147.9              | 5.1 <sup>a</sup> | 53 <sup>a</sup> | 5               | 2.3              |
|     | P2P1  | 8.7               | 5.44              | 16.9              | 49.6              | 187 | 146.7              | 5.2 <sup>a</sup> | 64              | 5               | 3.2 <sup>a</sup> |
| 10  | P2GPI | 9.3               | 5.55              | 17.2              | 51                | 177 | 147.8              | 4.9              | 54 <sup>a</sup> | 6               | 2.9              |
|     | HAPI  | 5.7               | 5.14              | 16.1              | 47                | 181 | 145.9              | 5.6 <sup>a</sup> | 61 <sup>a</sup> | 8               | Missing          |
|     | OP1   | 8.6               | 6.02 <sup>a</sup> | 18.4 <sup>a</sup> | 55.8 <sup>a</sup> | 187 | 147.6              | 5.3 <sup>a</sup> | 63 <sup>a</sup> | 9               | 1.5 <sup>a</sup> |
|     | 00    | 10.2 <sup>a</sup> | 5.77              | 17.9 <sup>a</sup> | 52.8              | 197 | 147.4              | 5.3 <sup>a</sup> | 67              | 17              | 1.7              |
|     | PIP1  | 11 <sup>a</sup>   | 5.63              | 17.3              | 51.9              | 217 | 147.7              | 5.4 <sup>a</sup> | 67              | 6               | 2.2              |
|     | P2P1  | 9.4               | 5.53              | 17                | 50.8              | 200 | 147.9              | 5.3 <sup>a</sup> | 71              | 6               | 2.4              |
| 30  | P2GPI | 10.6 <sup>a</sup> | 5.52              | 17.2              | 50.8              | 200 | 147.6              | 5.2 <sup>a</sup> | 83              | 9               | 2.9              |
|     | HAPI  | 8.7               | 5.43              | 17                | 49.9              | 197 | 146.9              | 5.4 <sup>a</sup> | 97              | 11              | 2.7              |
|     | OP1   | 9.5               | 6.01 <sup>a</sup> | 18.6 <sup>a</sup> | 56 <sup>a</sup>   | 196 | 148.1 <sup>a</sup> | 5.7 <sup>a</sup> | 92              | 13              | 1.1 <sup>a</sup> |
|     | 00    | 11.0 <sup>a</sup> | 5.89              | 18.2 <sup>a</sup> | 53.7 <sup>a</sup> | 207 | 148.1 <sup>a</sup> | 5.5 <sup>a</sup> | 65              | 23 <sup>a</sup> | 2.1              |
|     | PIP1  | 10.8 <sup>a</sup> | 5.55              | 17.3              | 50.9              | 226 | 147.4              | 5.5 <sup>a</sup> | 101             | 9               | 2.4              |
|     | P2P1  | 9.4               | 5.51              | 17                | 50.5              | 195 | 148.5              | 5.5 <sup>a</sup> | 101             | 6               | 2.8              |
| 70  | P2GPI | 9.7               | 5.61              | 17.3              | 51.2              | 202 | 147.6              | 5.4 <sup>a</sup> | 96              | 11              | 2.5              |
|     | HAPI  | 8.8               | 5.47              | 17                | 50.3              | 223 | 147.7              | 5.5 <sup>a</sup> | 96              | 11              | 2.3              |
|     | OP1   | 9.2               | 6.03 <sup>a</sup> | 18.7 <sup>a</sup> | 55.8 <sup>a</sup> | 220 | 146.2              | 5.7              | 104             | 11              | 2.7              |
|     | 00    | 13.0 <sup>a</sup> | 5.92 <sup>a</sup> | 18.4 <sup>a</sup> | 55.0 <sup>a</sup> | 235 | 148.4              | 5.5 <sup>a</sup> | 73              | 32 <sup>a</sup> | 2.8              |

Appendix 7. Continued

|      |       | Subject GUF |         |         |         |         |                    |                  |                  |                  |                  |
|------|-------|-------------|---------|---------|---------|---------|--------------------|------------------|------------------|------------------|------------------|
|      | PIP1  | 8.7         | 5.06    | 15.3    | 45.1    | 229     | 145.7              | 4.3              | 107              | 6                | 1.3 <sup>a</sup> |
|      | P2P1  | 5.2         | 5.57    | 16.9    | 49.4    | 226     | 146.4              | 3.9              | 111              | 6                | 1.7              |
| -105 | P2GPI | 5.3         | 5.28    | 16      | 47.6    | 209     | 145.9              | 4.5              | 113              | 7                | 0.8 <sup>a</sup> |
|      | HAP1  | 5.6         | 5.04    | 15.3    | 45.4    | 236     | 145.8              | 4.2              | 109              | 6                | 1.9              |
|      | OP1   | Clotted     | Clotted | Clotted | Clotted | Clotted | 146.2              | 4                | 132 <sup>a</sup> | 10               | 2.2              |
|      | 00    | 5.2         | 5.25    | 15.7    | 46.9    | 215     | 145.4              | 4.1              | 113              | 9                | 2.7              |
|      | PIP1  | 7.5         | 5.42    | 16.4    | 48.6    | 222     | 146.7              | 4.1              | 58 <sup>a</sup>  | 7                | -                |
|      | P2P1  | 4.4         | 5.51    | 16.8    | 49.3    | 217     | 148.3 <sup>a</sup> | 4                | 62 <sup>a</sup>  | 6                | -                |
| -35  | P2GPI | 5           | 5.37    | 16.4    | 48.1    | 213     | 148.1 <sup>a</sup> | 4.7              | 80               | 74 <sup>a</sup>  | -                |
|      | HAP1  | 4.9         | 5.06    | 15.5    | 45.5    | 196     | 147.9              | 4.7              | 66               | 5                | -                |
|      | OP1   | 4.4         | 5.07    | 15.5    | 45.1    | 236     | 146.9              | 4.3              | 95               | 7                | -                |
|      | 00    | 5.8         | 5.53    | 16.6    | 49      | 249     | 145.7              | 4.4              | 74               | 8                | -                |
|      | PIP1  | 7.2         | 5.46    | 16.5    | 49      | 229     | 147.8              | 3.8              | 59 <sup>a</sup>  | 11               | -                |
|      | P2P1  | 4.3         | 5.48    | 16.7    | 49.1    | 215     | 148.4 <sup>a</sup> | 3.8              | 50 <sup>a</sup>  | 8                | -                |
| -25  | P2GPI | 5           | 5.2     | 15.9    | 47.1    | 214     | 150.3 <sup>a</sup> | 5.9 <sup>a</sup> | 111              | 140 <sup>a</sup> | -                |
|      | HAP1  | 5.1         | 5.1     | 15.6    | 46      | 211     | 149 <sup>a</sup>   | 5.2 <sup>a</sup> | 76               | 8                | -                |
|      | OP1   | 3.9         | 5.18    | 15.8    | 46.4    | 229     | 147                | 4.1              | 82               | 13               | -                |
|      | 00    | 4.4         | 5.55    | 16.6    | 49.4    | 203     | 147.7              | 4.2              | 66               | 23 <sup>a</sup>  | -                |
|      | PIP1  | 7.2         | 5.54    | 16.7    | 49.6    | 219     | 148.1 <sup>a</sup> | 3.8              | 48 <sup>a</sup>  | 16               | 3.5 <sup>a</sup> |
|      | P2P1  | 4.8         | 5.51    | 16.7    | 49.4    | 219     | 148.8 <sup>a</sup> | 3.5              | 52 <sup>a</sup>  | 9                | 2.3              |
| 0    | P2GPI | 5.2         | 5.07    | 15.6    | 45.6    | 240     | 146.4              | 3.6              | 57 <sup>a</sup>  | 122 <sup>a</sup> | 1.8              |
|      | HAP1  | 5.3         | 5.14    | 15.6    | 46.4    | 218     | 148.4 <sup>a</sup> | 5.1 <sup>a</sup> | 68               | 8                | 3.7 <sup>a</sup> |
|      | OP1   | 4.7         | 5.22    | 16.1    | 46.9    | 232     | 148.3 <sup>a</sup> | 4                | 64               | 13               | 2.4              |
|      | 00    | 4.8         | 5.65    | 17      | 50      | 211     | 144.6              | 4.6              | 57 <sup>a</sup>  | 20 <sup>a</sup>  | 2                |
|      | PIP1  | 9.2         | 5.69    | 17.1    | 50.9    | 257     | 149 <sup>a</sup>   | 4.5              | 42 <sup>a</sup>  | 20 <sup>a</sup>  | 3.4 <sup>a</sup> |
|      | P2P1  | 5.8         | 5.64    | 17      | 50.3    | 246     | 149.2 <sup>a</sup> | 4.1              | 35 <sup>a</sup>  | 9                | 2.7              |
| 10   | P2GPI | 6.4         | 5.23    | 16      | 47.1    | 244     | 147.9              | 4.4              | 34 <sup>a</sup>  | 121 <sup>a</sup> | 2.2              |
|      | HAP1  | 6.4         | 5.13    | 15.6    | 45.9    | 240     | 148.9 <sup>a</sup> | 4.3              | 51 <sup>a</sup>  | 10               | 3.7 <sup>a</sup> |
|      | OP1   | 5.9         | 5.48    | 16.7    | 48.9    | 256     | 149.8 <sup>a</sup> | 4.7              | 66               | 13               | 2.4              |
|      | 00    | 6.1         | 5.86    | 17.1    | 52.1    | 226     | 144.9              | 4.5              | 70               | 13               | 3.7 <sup>a</sup> |

## Appendix 7. Continued

|             |       |     |                   |                   |                   |     |                    |                  |                  |                  |                  |
|-------------|-------|-----|-------------------|-------------------|-------------------|-----|--------------------|------------------|------------------|------------------|------------------|
|             | PIPI  | 9.1 | 5.54              | 16.7              | 49.4              | 267 | 148.6 <sup>a</sup> | 5.3 <sup>a</sup> | 64               | 12               | 1.8              |
|             | P2PI  | 6.4 | 5.44              | 16.5              | 48.7              | 264 | 148.5 <sup>a</sup> | 5.1 <sup>a</sup> | 66               | 8                | 2                |
| 30          | P2GPI | 6.6 | 5.19              | 16                | 46.5              | 234 | 148.1 <sup>a</sup> | 5                | 58 <sup>a</sup>  | 139 <sup>a</sup> | 1.9              |
|             | HAPI  | 6.3 | 4.97              | 15.3              | 44.6              | 235 | 147.2              | 5.3 <sup>a</sup> | 82               | 9                | 3                |
|             | OP1   | 6   | 5.37              | 16.3              | 48.2              | 268 | 148.9 <sup>a</sup> | 5                | 77               | 15               | 1.6 <sup>a</sup> |
|             | 00    | 5.9 | 5.59              | 16.8              | 49.8              | 236 | 144.9              | 4.9              | 77               | 14               | 2.6              |
|             | PIPI  | 8.7 | 5.46              | 16.5              | 48.9              | 281 | 149.3 <sup>a</sup> | 5.2 <sup>a</sup> | 72               | 15               | 1.9              |
|             | P2PI  | 6.3 | 5.46              | 16.6              | 49.2              | 273 | 149.9 <sup>a</sup> | 5.3 <sup>a</sup> | 75               | 10               | 2.5              |
| 70          | P2GPI | 6   | 5.2               | 15.8              | 46.7              | 267 | 148.7 <sup>a</sup> | 5.1 <sup>a</sup> | 70               | 120 <sup>a</sup> | 1.9              |
|             | HAPI  | 6.1 | 4.98              | 15.2              | 44.7              | 241 | 148.3 <sup>a</sup> | 5.3 <sup>a</sup> | 94               | 10               | 2.6              |
|             | OP1   | 5.5 | 5.26              | 16.2              | 46.5              | 294 | 148.1 <sup>a</sup> | 4.9              | 98               | 14               | 1.8              |
|             | 00    | 4.9 | 5.59              | 16.6              | 49.8              | 184 | 154.4 <sup>a</sup> | 5.3 <sup>a</sup> | 88               | 17               | 2.2              |
| Subject PAU |       |     |                   |                   |                   |     |                    |                  |                  |                  |                  |
|             | PIPI  | 4.4 | 5.16              | 15.7              | 45.7              | 232 | 145.9              | 4.5              | 138 <sup>a</sup> | 4                | 1.8              |
|             | P2PI  | 4.1 | 5.08              | 15.5              | 45                | 230 | 144.6              | 4.3              | 146 <sup>a</sup> | 4                | 1.9              |
| -105        | P2GPI | 4   | 5.3               | 16.1              | 47                | 230 | 144.7              | 4.3              | 156 <sup>a</sup> | 5                | 2.2              |
|             | HAPI  | 4.4 | 5.25              | 16                | 46.6              | 238 | 143.9              | 4.4              | 150 <sup>a</sup> | 8                | 2                |
|             | OP1   | 4.8 | 5.95 <sup>a</sup> | 17.7 <sup>a</sup> | 52.7              | 228 | 145.3              | 4.5              | 114 <sup>a</sup> | 7                | 2.7              |
|             | 00    | 4.6 | 5.37              | 16                | 47.8              | 213 | 141.2              | 4.1              | 146 <sup>a</sup> | 5                | 1.6 <sup>a</sup> |
|             | PIPI  | 4.4 | 5.05              | 15.4              | 44.9              | 218 | 145.7              | 4.3              | 131 <sup>a</sup> | 4                | -                |
|             | P2PI  | 3.8 | 5.06              | 15.3              | 44.6              | 225 | 146.6              | 4.5              | 107              | 4                | -                |
| -35         | P2GPI | 4.1 | 5.17              | 15.8              | 46.1              | 223 | 146.3              | 4.4              | 130 <sup>a</sup> | 80 <sup>a</sup>  | -                |
|             | HAPI  | 4.2 | 5.1               | 15.5              | 45.1              | 232 | 145.5              | 4.5              | 76               | 6                | -                |
|             | OP1   | 4.5 | 5.91 <sup>a</sup> | 17.5              | 53.1 <sup>a</sup> | 225 | 144.6              | 5.1 <sup>a</sup> | 108              | 5                | -                |
|             | 00    | 4.8 | 5.18              | 15.6              | 46.2              | 216 | 141.8              | 4.4              | 105              | 5                | -                |
|             | PIPI  | 4.4 | 5.14              | 15.6              | 45.7              | 218 | 145.6              | 4.4              | 123 <sup>a</sup> | 23 <sup>a</sup>  | -                |
|             | P2PI  | 3.9 | 5.02              | 15.3              | 44.5              | 217 | 146.7              | 4.4              | 102              | 6                | -                |
| -25         | P2GPI | 4   | 5.15              | 15.7              | 45.7              | 230 | 146.7              | 4.3              | 133 <sup>a</sup> | 105 <sup>a</sup> | -                |
|             | HAPI  | 4.4 | 5.07              | 15.4              | 44.7              | 236 | 146.3              | 4.6              | 73               | 8                | -                |
|             | OP1   | 4.8 | 5.83              | 17.6 <sup>a</sup> | 51.8              | 216 | 144.8              | 4.7              | 112              | 7                | -                |
|             | 00    | 5.1 | 5.21              | 15.5              | 46.4              | 221 | 143.3              | 4.4              | 98               | 17               | -                |

Appendix 7. Continued

|      |             |     |                   |                   |                   |     |       |                  |                  |                  |                  |
|------|-------------|-----|-------------------|-------------------|-------------------|-----|-------|------------------|------------------|------------------|------------------|
|      | PIPI        | 4.5 | 5.03              | 15.3              | 44.9              | 221 | 145.9 | 4.5              | 113              | 6                | 2.3              |
|      | P2PI        | 4.4 | 5.11              | 15.6              | 45.1              | 225 | 146.4 | 4.4              | 98               | 5                | 2.9              |
| 0    | P2GPI       | 4.6 | 5.23              | 15.7              | 46.5              | 203 | 146.4 | 4.4              | 122 <sup>a</sup> | 137 <sup>a</sup> | 2.6              |
|      | HAPI        | 4.3 | 4.95              | 15.2              | 43.5              | 226 | 145.6 | 4.9              | 74               | 8                | 4                |
|      | OP1         | 5   | 5.89              | 17.8 <sup>a</sup> | 52.3              | 219 | 144.7 | 4.6              | 113              | 8                | 2.1              |
|      | 00          | 5.3 | 5.23              | 15.8              | 47.1              | 231 | 142.9 | 4.7              | 90               | 12               | 1.5 <sup>a</sup> |
|      | PIPI        | 6.6 | 5.32              | 16.1              | 47.4              | 253 | 148   | 5.1 <sup>a</sup> | 84               | 6                | 2.3              |
|      | P2PI        | 6.1 | 5.31              | 16.2              | 47.2              | 262 | 148.7 | 5.4 <sup>a</sup> | 78               | 14               | 2.9              |
| 10   | P2GPI       | 6.2 | 5.46              | 16.7              | 48.8              | 255 | 148.2 | 4.9              | 119 <sup>a</sup> | 157 <sup>a</sup> | 2.4              |
|      | HAPI        | 6.4 | 5.3               | 16.2              | 47.2              | 252 | 147.1 | 5.5 <sup>a</sup> | 106              | 9                | 3                |
|      | OP1         | 8.3 | 6.26 <sup>a</sup> | 18.7 <sup>a</sup> | 56 <sup>a</sup>   | 248 | 147.6 | 5.6 <sup>a</sup> | 90               | 9                | 2.3              |
|      | 00          | 7.4 | 5.54              | 16.8              | 50.1              | 251 | 146.3 | 5.3 <sup>a</sup> | 92               | 18 <sup>a</sup>  | 1.5 <sup>a</sup> |
|      | PIPI        | 7.1 | 5.39              | 16.3              | 47.8              | 290 | 147.7 | 5.1 <sup>a</sup> | 84               | 10               | 2.6              |
|      | P2PI        | 7   | 5.38              | 16.3              | 48.2              | 290 | 148.4 | 5.2 <sup>a</sup> | 89               | 11               | 3                |
| 30   | P2GPI       | 7.4 | 5.49              | 16.7              | 49                | 265 | 148.8 | 5.2 <sup>a</sup> | 97               | 139 <sup>a</sup> | 3                |
|      | HAPI        | 6.6 | 5.28              | 16                | 47                | 264 | 147.4 | 5.9 <sup>a</sup> | 111              | 12               | 2.9              |
|      | OP1         | 8.9 | 6.37 <sup>a</sup> | 19.2 <sup>a</sup> | 57.1 <sup>a</sup> | 289 | 147.9 | 5.8 <sup>a</sup> | 102              | 15               | 2.9              |
|      | 00          | 7.7 | 5.66              | 17                | 50.9              | 257 | 147.3 | 5.4 <sup>a</sup> | 78               | 17               | 1.8              |
|      | PIPI        | 6.4 | 5.25              | 15.8              | 46.8              | 284 | 146.4 | 5.3 <sup>a</sup> | 114              | 7                | 2.9              |
|      | P2PI        | 6.7 | 5.28              | 16.1              | 46.9              | 287 | 147.5 | 5.4 <sup>a</sup> | 107              | 6                | 3.1 <sup>a</sup> |
| 70   | P2GPI       | 6.7 | 5.48              | 16.5              | 48.7              | 317 | 147.4 | 5.2 <sup>a</sup> | 123 <sup>a</sup> | 80 <sup>a</sup>  | 3.5 <sup>a</sup> |
|      | HAPI        | 6.4 | 5.21              | 15.8              | 46.1              | 287 | 146.3 | 5.6 <sup>a</sup> | 114              | 12               | 2.8              |
|      | OP1         | 8.9 | 6.21 <sup>a</sup> | 18.2 <sup>a</sup> | 55.4 <sup>a</sup> | 335 | 148.9 | 6.1 <sup>a</sup> | 142 <sup>a</sup> | 21 <sup>a</sup>  | 3.3 <sup>a</sup> |
|      | 00          | 7.7 | 5.57              | 16.8              | 50                | 286 | 148   | 5.6 <sup>a</sup> | 84               | 27 <sup>a</sup>  | 2.1              |
|      | Subject PED |     |                   |                   |                   |     |       |                  |                  |                  |                  |
|      | PIPI        | 4.5 | 5.06              | 15.6              | 45.7              | 191 | 147.4 | 4.6              | 115              | 5                | 1.9              |
|      | P2PI        | 6.4 | 5.23              | 16.2              | 47.5              | 191 | 143.3 | 3.8              | 138 <sup>a</sup> | 7                | 2                |
| -105 | P2GPI       | 4.9 | 4.85              | 15.1              | 44.1              | 173 | 146.4 | 4.2              | 121 <sup>a</sup> | 3                | 1.8              |
|      | HAPI        | 6   | 5.09              | 15.9              | 46.3              | 196 | 146.3 | 4.5              | 114              | 5                | 1.5 <sup>a</sup> |
|      | OP1         | 6.2 | 5.16              | 15.9              | 47                | 174 | 144.8 | 4.2              | 132 <sup>a</sup> | 8                | 2.4              |
|      | 00          | 4.6 | 5.23              | 16.2              | 47.5              | 175 | 145.8 | 4.4              | 123 <sup>a</sup> | 5                | 2.4              |

Appendix 7. Continued

|     |       |     |      |      |      |     |       |                  |                  |                  |                  |
|-----|-------|-----|------|------|------|-----|-------|------------------|------------------|------------------|------------------|
|     | PIP1  | 4   | 4.88 | 15.3 | 44.4 | 200 | 148.1 | 4.9              | 104              | 4                | -                |
|     | P2P1  | 5.1 | 5.17 | 16.1 | 47   | 188 | 147.2 | 3.5              | 124 <sup>a</sup> | 6                | -                |
| -35 | P2GP1 | 4.6 | 4.93 | 15.3 | 45.2 | 189 | 146.9 | 4                | 85               | 218 <sup>a</sup> | -                |
|     | HAPI  | 4.8 | 4.96 | 15.4 | 45.8 | 201 | 148   | 4.1              | 61 <sup>a</sup>  | 3                | -                |
|     | OP1   | 5.7 | 5.37 | 16.4 | 48.9 | 214 | 147.2 | 4.5              | 79               | 6                | -                |
|     | 00    | 4.4 | 5.13 | 16   | 47.1 | 180 | 147   | 4.5              | 87               | 5                | -                |
|     | PIP1  | 4.1 | 4.84 | 15   | 44.1 | 183 | 148.3 | 4.4              | 115              | 5                | -                |
|     | P2P1  | 5.2 | 5.19 | 16.1 | 47.4 | 188 | 146.9 | 3.5              | 122 <sup>a</sup> | 13               | -                |
| -25 | P2GP1 | 4.5 | 4.93 | 15.5 | 45.6 | 188 | 148.2 | 3.9              | 71               | 262 <sup>a</sup> | -                |
|     | HAPI  | 4.8 | 4.8  | 15   | 44.1 | 193 | 147.1 | 4                | 62 <sup>a</sup>  | 5                | -                |
|     | OP1   | 5.7 | 5.25 | 16.3 | 47.9 | 198 | 146.5 | 4.5              | 74               | 9                | -                |
|     | 00    | 4.5 | 5.1  | 16   | 47   | 171 | 146.9 | 4.5              | 67               | 14               | -                |
|     | PIP1  | 3.9 | 4.92 | 15.4 | 44.6 | 186 | 147.7 | 4.2              | 52 <sup>a</sup>  | 6                | 2.3              |
|     | P2P1  | 5.9 | 5.17 | 16.3 | 47.1 | 194 | 146.5 | 3.5              | 106              | 8                | 2.9              |
| 0   | P2GP1 | 5   | 4.98 | 15.5 | 45.6 | 183 | 148   | 4                | 68               | 326 <sup>a</sup> | 2.7              |
|     | HAPI  | 5   | 4.83 | 15.2 | 44.6 | 194 | 146.8 | 4                | 44 <sup>a</sup>  | 5                | 3.3              |
|     | OP1   | 6.4 | 5.52 | 16.9 | 50.4 | 175 | 148.3 | 4.6              | 54 <sup>a</sup>  | 9                | 2.4              |
|     | 00    | 5.3 | 5.31 | 16.5 | 48.5 | 182 | 147.2 | 4.7              | 56 <sup>a</sup>  | 8                | 2                |
|     | PIP1  | 5.6 | 5.04 | 15.8 | 45.8 | 175 | 147.9 | 4.8              | 56 <sup>a</sup>  | 6                | 2.1              |
|     | P2P1  | 7.6 | 5.31 | 16.5 | 48.7 | 223 | 147.2 | 4.2              | 79               | 11               | 2.6              |
| 10  | P2GP1 | 6.3 | 5.14 | 16   | 47.1 | 240 | 148.9 | 4.4              | 59 <sup>a</sup>  | 303 <sup>a</sup> | 2.8              |
|     | HAPI  | 6.6 | 5.01 | 15.6 | 46.2 | 204 | 147.8 | 4.7              | 63 <sup>a</sup>  | 6                | 2.3              |
|     | OP1   | 8.1 | 5.54 | 16.9 | 50.8 | 195 | 146.9 | 5.3 <sup>a</sup> | 61 <sup>a</sup>  | 16               | 2.1              |
|     | 00    | 6.8 | 5.38 | 16.7 | 49.3 | 202 | 148.9 | 4.7              | 63               | 11               | 2                |
|     | PIP1  | 5.6 | 5.06 | 15.8 | 46.7 | 191 | 147.8 | 5.1              | 68               | 8                | 2.5              |
|     | P2P1  | 8   | 5.36 | 16.7 | 48.5 | 251 | 148.5 | 4.5              | 70               | 11               | 2.3              |
| 30  | P2GP1 | 6.2 | 5.06 | 15.8 | 46.3 | 192 | 148.6 | 4.9              | 69               | 282 <sup>a</sup> | 2.4              |
|     | HAPI  | 6.4 | 5.03 | 15.6 | 46.1 | 180 | 146.2 | 4.8              | 99               | 5                | 2.5              |
|     | OP1   | 8   | 5.43 | 16.7 | 49.5 | 174 | 147.3 | 5.1              | 82               | 9                | 1.8              |
|     | 00    | 6.4 | 5.32 | 16.6 | 48.6 | 206 | 148.2 | 5                | 82               | 11               | 1.5 <sup>a</sup> |

Appendix 7. Continued

|                    |       |                  |         |         |         |         |       |                  |                  |                  |                  |
|--------------------|-------|------------------|---------|---------|---------|---------|-------|------------------|------------------|------------------|------------------|
|                    | PIPI  | 5.2              | 4.87    | 15.3    | 44.4    | 179     | 147.1 | 5.2              | 95               | 6                | 2.8              |
|                    | P2PI  | 8.3              | 5.25    | 16.6    | 48.2    | 129     | 146.4 | 4.7              | 101              | 9                | 2.5              |
| 70                 | P2GPI | 6.1              | 5.02    | 15.8    | 45.9    | 219     | 148.9 | 4.9              | 84               | 188 <sup>a</sup> | 2.6              |
|                    | HAPI  | 6.5              | 4.97    | 15.4    | 45.9    | 202     | 146.3 | 4.9              | 95               | 6                | 2.1              |
|                    | OP1   | 7.3              | 5.31    | 16.3    | 48.7    | 255     | 140.6 | 5                | 103              | 10               | 2                |
|                    | 00    | 6                | 5.08    | 16.5    | 47.1    | 241     | 146.7 | 5.2 <sup>a</sup> | 87               | 11               | 1.6 <sup>a</sup> |
| <b>Subject REA</b> |       |                  |         |         |         |         |       |                  |                  |                  |                  |
|                    | PIPI  | 2.9              | 5.7     | 16.2    | 47.5    | 251     | 144.9 | 4.2              | 121 <sup>a</sup> | 9                | 1.1 <sup>a</sup> |
|                    | P2PI  | 4.3              | 5.43    | 15.5    | 45.7    | 290     | 145.1 | 4.1              | 142 <sup>a</sup> | 10               | 0.9 <sup>a</sup> |
| -105               | P2GPI | 3.2 <sup>a</sup> | 5.63    | 16.2    | 47.4    | 292     | 143.8 | 4.1              | 126 <sup>a</sup> | 8                | 1.1 <sup>a</sup> |
|                    | HAPI  | 3.2 <sup>a</sup> | 5.61    | 15.9    | 47.1    | 292     | 143.5 | 4.1              | 127 <sup>a</sup> | 9                | 0.9 <sup>a</sup> |
|                    | OP1   | 4                | 5.54    | 15.9    | 46.5    | 268     | 144.2 | 4.4              | 125 <sup>a</sup> | 6                | 0.9 <sup>a</sup> |
|                    | 00    | 2.7 <sup>a</sup> | 5.55    | 15.8    | 46.8    | 278     | 145.4 | 4.2              | 152 <sup>a</sup> | 8                | 0.7 <sup>a</sup> |
|                    | PIPI  | 2.5              | 5.42    | 15.5    | 45.3    | 284     | 142.3 | 4                | 132 <sup>a</sup> | 9                | -                |
|                    | P2PI  | 4.7              | 5.34    | 15.3    | 44.9    | 317     | 145.4 | 4                | 173 <sup>a</sup> | 7                | -                |
| -35                | P2GPI | 2.8 <sup>a</sup> | 5.52    | 16      | 46.5    | 305     | 143.1 | 4.2              | 143 <sup>a</sup> | 68               | -                |
|                    | HAPI  | 3.2 <sup>a</sup> | 5.35    | 15.1    | 44.9    | 283     | 143.8 | 4.5              | 97               | 8                | -                |
|                    | OP1   | 4.9              | 5.51    | 15.7    | 46.5    | 284     | 144.8 | 4.5              | 105              | 6                | -                |
|                    | 00    | 2.4 <sup>a</sup> | 5.52    | 15.9    | 46.9    | 259     | 146.1 | 4.6              | 127 <sup>a</sup> | 7                | -                |
|                    | PIPI  | 2.5              | 5.43    | 15.6    | 45.1    | 261     | 142.6 | 3.88             | 130 <sup>a</sup> | 10               | -                |
|                    | P2PI  | 4.7              | 5.35    | 15.3    | 45.1    | 300     | 146.3 | 3.8              | 164 <sup>a</sup> | 15               | -                |
| -25                | P2GPI | 2.8 <sup>a</sup> | 5.51    | 15.9    | 46.7    | 300     | 145.6 | 4.1              | 141 <sup>a</sup> | 47               | -                |
|                    | HAPI  | 3.2 <sup>a</sup> | 5.3     | 15.4    | 44.5    | 272     | 143.4 | 4.28             | 98               | 9                | -                |
|                    | OP1   | 5                | 5.46    | 15.8    | 46.2    | 309     | 144.9 | 4.5              | 115              | 9                | -                |
|                    | 00    | 2.4 <sup>a</sup> | 5.5     | 15.6    | 46.3    | 270     | 146.2 | 4.5              | 134 <sup>a</sup> | 9                | -                |
|                    | PIPI  | Missing          | Missing | Missing | Missing | Missing | 142.1 | 4.2              | 103              | 10               | 1.0 <sup>a</sup> |
|                    | P2PI  | 5.2              | 5.34    | 15.3    | 44.5    | 336     | 146.4 | 3.9              | 147 <sup>a</sup> | 12               | 1.1 <sup>a</sup> |
| 0                  | P2GPI | 3 <sup>a</sup>   | 5.5     | 15.7    | 46.2    | 300     | 143.4 | 4.3              | 168 <sup>a</sup> | 159              | 1.0 <sup>a</sup> |
|                    | HAPI  | 3.3 <sup>a</sup> | 5.36    | 15.1    | 44.6    | 228     | 142.9 | 4.3              | 102              | 10               | 2.1              |
|                    | OP1   | 5.4              | 5.41    | 15.7    | 45.7    | 319     | 144.8 | 4.7              | 113              | 8                | 0.7 <sup>a</sup> |
|                    | 00    | 2.6 <sup>a</sup> | 5.51    | 15.8    | 46.4    | 271     | 145.7 | 4.6              | 121 <sup>a</sup> | 9                | 0.7 <sup>a</sup> |

## Appendix 7. Concluded

|    |       |         |         |         |         |         |       |                  |                  |     |                  |
|----|-------|---------|---------|---------|---------|---------|-------|------------------|------------------|-----|------------------|
| 10 | PIP1  | 5       | 5.65    | 16.1    | 47.5    | 283     | 143.7 | 5                | 82               | 11  | 1.1 <sup>a</sup> |
|    | P2P1  | 6.8     | 5.45    | 15.9    | 45.7    | 341     | 148.2 | 4.4              | 110              | 20  | 1.1 <sup>a</sup> |
|    | P2GPI | 4.4     | 5.68    | 16.4    | 48      | 323     | 146.2 | 4.7              | 114              | 123 | 1.0 <sup>a</sup> |
|    | HAPI  | 3.9     | 5.52    | 15.8    | 46.5    | 306     | 147.2 | 4.9              | 97               | 11  | 2                |
|    | OP1   | 6.9     | 5.64    | 16.4    | 47.8    | 316     | 147.4 | 5.1              | 98               | 10  | 1.0 <sup>a</sup> |
|    | 00    | 3.8     | 5.73    | 16.5    | 48.3    | 268     | 148.3 | 5.1              | 92               | 11  | 1.0 <sup>a</sup> |
|    | PIP1  | Clotted | Clotted | Clotted | Clotted | Clotted | 143.1 | 5.7 <sup>a</sup> | 94               | 14  | 2.1              |
|    | P2P1  | 7.6     | 5.61    | 16.1    | 47.3    | 345     | 148.6 | 4.8              | 108              | 19  | 1.0 <sup>a</sup> |
|    | P2GPI | 4.5     | 5.68    | 16.3    | 48.1    | 349     | 146.2 | 5                | 112              | 139 | 1.3 <sup>a</sup> |
|    | HAPI  | 4.3     | 5.48    | 15.6    | 46.1    | 315     | 145.3 | 5                | 102              | 10  | 1.8              |
|    | OP1   | 7.3     | 5.6     | 16.2    | 47.8    | 315     | 146.8 | 5.2              | 118 <sup>a</sup> | 9   | 0.9 <sup>a</sup> |
|    | 00    | 3.6     | 5.73    | 16.5    | 48.6    | 288     | 148.8 | 5.4 <sup>a</sup> | 94               | 12  | 0.9 <sup>a</sup> |
|    | PIP1  | 3.3     | 5.61    | 15.9    | 47      | 353     | 141.7 | 5.2 <sup>a</sup> | 110              | 12  | 1.4 <sup>a</sup> |
|    | P2P1  | 8       | 5.48    | 16      | 45.8    | 382     | 147.9 | 5.2 <sup>a</sup> | 117              | 18  | 1.4 <sup>a</sup> |
|    | P2GPI | 4.4     | 5.61    | 16.2    | 47.3    | 362     | 146.1 | 5.4 <sup>a</sup> | 122 <sup>a</sup> | 130 | 1.7              |
|    | HAPI  | 4.2     | 5.36    | 15.6    | 45      | 309     | 146.6 | 5.3 <sup>a</sup> | 105              | 10  | 1.5 <sup>a</sup> |
|    | OP1   | 7.5     | 5.54    | 16.1    | 46.8    | 301     | 146.6 | 5.3 <sup>a</sup> | 106              | 8   | 1.2 <sup>a</sup> |
|    | 00    | 3.6     | 5.66    | 16.2    | 47.8    | 277     | 148.1 | 5.7 <sup>a</sup> | 91               | 12  | 1.3 <sup>a</sup> |

<sup>a</sup>Abnormal value.<sup>b</sup>Equivalent triglyceride concentration.

# REPORT DOCUMENTATION PAGE

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| <b>13. ABSTRACT (Maximum 200 words)</b><br>To test the hypothesis that drink composition is more important than drink osmolality (Osm) for maintaining and increasing plasma volume (PV) at rest and during exercise, six men (22-39 yr, 76.84 ± 16.19 kg, 2.99 ± 0.45 L/min $\dot{V}O_2$ peak) each underwent six treatments while sitting for 90 min ( $\dot{V}O_2 = 0.39$ L/min) and then performed upright ergometer exercise for 70 min ( $\dot{V}O_2 = 2.08 \pm 0.33$ l/min, 70% ± 7% $\dot{V}O_2$ peak). Drink formulations (10 ml/kg body weight, $\bar{X} = 768$ ml) for the sitting period were: P1 (55 mEq Na <sup>+</sup> , 365 mOsm/kg H <sub>2</sub> O), P2 (97.1 mEq Na <sup>+</sup> , 791 mOsm/kg), P2G (113 mEq Na <sup>+</sup> , 80 ml glycerol, 1,382 mOsm/kg), HyperAde (HA) (164 mEq Na <sup>+</sup> , 253 mOsm/kg), and 01 and 02 (no drinking). The exercise drink (10 ml/kg, 768 ml) was P1 for all treatments except 02. Plasma volume at rest increased (p < 0.05) by 4.7% with P1 and by 7.9% with HA. Percent change in PV during exercise was +1% to +3% (NS) with HA; -6% to 0% (NS) with P1, P2, P2G, and 01; and -8% to -5% (p < 0.05) with 02. HyperAde, with the lowest osmolality (253 mOsm/kg), maintained PV at rest and during exercise, whereas the other drinks with lower Na <sup>+</sup> 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. |                                                                 |                                                |                                                                           |  |
| <b>14. SUBJECT TERMS</b><br>Hypervolemia, Drinking, Hyperhydration, Exercise                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                 |                                                | <b>15. NUMBER OF PAGES</b><br>54                                          |  |
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