

SUCROSE INGESTION AND PHYSICAL PERFORMANCE IN A COLD ENVIRONMENT

H. Rintamäki, T. Mäkinen and J. Oksa

Oulu Regional Institute of Occupational Health, Aapistie 1, FIN-90220 Oulu,
Finland.

INTRODUCTION

During exercise in cold conditions, increased need for and decreased consumption of water can produce a gradual dehydration and simultaneous diminution of physical performance (1). Due to peripheral vasoconstriction, plasma volume is decreased by acute exposure to cold, too. Decreased plasma volume and physical performance can be restored to a certain extent by ingestion of liquids (1). However, the optimal composition of ingested liquids in a cold environment is still an open question. The aim of this study was to compare the effects of water and carbohydrate solution on water and carbohydrate balance, physical performance and thermoregulation in cold environment.

MATERIALS AND METHODS

Voluntary healthy young men (age 21.7 ± 2.6 years (mean \pm SD), weight 74.2 ± 9.2 kg, height 179 ± 6 cm, $n = 6$) served as test subjects. They wore winter clothing with thermal insulation of ca. 2.0 clo. The test subjects walked on a treadmill at -15 °C (air velocity $2 \text{ m}\cdot\text{s}^{-1}$) with a velocity of $5 \text{ km}\cdot\text{h}^{-1}$ for 6 h. Each 50 min walking was followed by a 10 min rest. Every 30 min the subjects ingested liquid (250 ml, water or 5 % sucrose solution in different test series). In the beginning of each rest period, a maximal rebound jump test (Ergojump, Newtest, Finland) was performed. The jumping test was started from 90° knee angle.

Heart rate was measured (Sport-Tester, Polar-Electro, Finland) continuously and recorded at 60 s intervals. Blood pressure (ABPM-Meditech, Meditech KFT, Budapest, Hungary) and oxygen consumption (Medikro M202, Medikro Oy, Kuopio, Finland) were measured at the end of each walking period.

Skin (13 sites) and rectal (T_{rekt} , 10 cm depth) were measured (YSI-400 series, Yellow Springs, USA) continuously and recorded (Squirrel 1200, Grant, England) at 60 s intervals. Mean skin temperature (T_{sk}) was calculated by weighing local skin temperatures by representative skin areas. Mean body temperature (T_{b}) was calculated by the equation: $T_{\text{b}} = T_{\text{sk}} \cdot 0.35 + T_{\text{rekt}} \cdot 0.65$. In the calculation of body heat content the specific heat of the body was estimated to be $4.18 \text{ kJ}\cdot\text{kg}^{-1}$.

Before and after the cold exposure the test subjects and their clothing were weighed (Mettler ID 1 Multirange, Mettler-Toledo GmbH, Albstadt, Germany) for the calculation of sweating and moisture accumulation into clothing.

Blood samples were collected before the cold exposure and thereafter for hematological analysis (Coulter T540, England) and glucose determination. Plasma and blood volume changes were calculated according to Dill and Costill (2). Blood glucose concentration was determined by photometric glucose dehydrogenase method.

Thermal sensations (3), ratings of perceived exertion (RPE, 4) and sensations of thirst and hunger (linear 5-point scale) were recorded at the end of each work period.

RESULTS

During the exercise, blood glucose was decreased from the initial $4.62 \text{ mmol}\cdot\text{l}^{-1}$ to 4.15 ± 0.5 (mean \pm SE) and $3.50 \pm 0.8 \text{ mmol}\cdot\text{l}^{-1}$ ($p < 0.05$) in sucrose and water groups, respectively. Sensation of hunger was significantly ($p < 0.05$) higher in the water group but there was no statistically significant difference in the sensation of thirst. Maximal jump height was not affected by sucrose. Heart rate was ca. $10 \text{ beats}\cdot\text{min}^{-1}$ lower in the sucrose group but blood pressure and plasma volume were unaffected. There was no significant difference in oxygen consumption, but at the end of the cold exposure, RQ was 0.86 ± 0.01 and 0.77 ± 0.01 ($p < 0.001$) in sucrose and water groups, respectively. At the end of exercise the number of leukocytes was significantly ($p < 0.05$) lower in the sucrose group ($9.2 \pm 1.6 \cdot 10^9 \cdot \text{l}^{-1}$) in comparison to water group ($13.3 \pm 4.4 \cdot 10^9 \cdot \text{l}^{-1}$).

Skin temperatures of thigh, calf and hand were ca. 1°C , and toe temperature even ca. 2°C higher (fig. 1) in the sucrose group ($p < 0.05 - 0.01$). Mean skin temperature was on the average 28.5°C and the quality of the drink had no effect on that. Thermal sensations did not significantly differ between the groups.

CONCLUSIONS

The ingestion of 5 % sucrose did correspond with about 25 % of total energy consumption during the experiment. The results show that sucrose ingestion helped to maintain a higher blood glucose level which was accompanied by weaker sensation of hunger, less activated immunodefence system and higher peripheral skin temperatures. According to Kayashima et al. (5) the leukocyte count of $9.5 \cdot 10^9 \cdot \text{l}^{-1}$ could mean changes in liver function. After water ingestion the count was clearly higher but after sucrose ingestion it was below the limit. Lower peripheral skin temperatures in the water group could be due to the increased need of energy conservation.

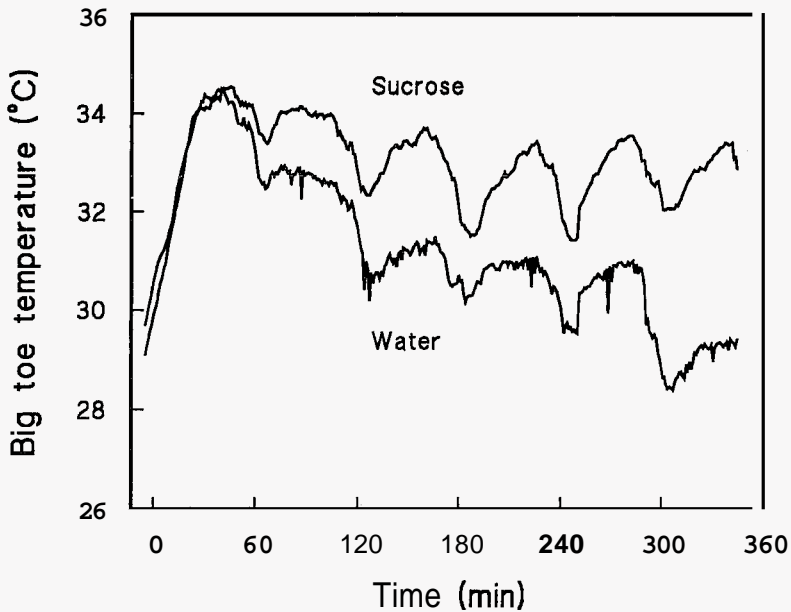


Figure. 1. Skin temperature of the big toe. The lines describe the mean of 6 subjects in the sucrose (upper line) and water groups.

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