

ORIGINAL ARTICLE

P. Šrámek · M. Šimečková · L. Janský
J. Šavlíková · S. Vybíral

Human physiological responses to immersion into water of different temperatures

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Abstract To differentiate between the effect of cold and hydrostatic pressure on hormone and cardiovascular functions of man, a group of young men was examined during 1-h head-out immersions in water of different temperatures (32°C, 20°C and 14°C). Immersion in water at 32°C did not change rectal temperature and metabolic rate, but lowered heart rate (by 15%) and systolic and diastolic blood pressures (by 11%, or 12%, respectively), compared to controls at ambient air temperature. Plasma renin activity, plasma cortisol and aldosterone concentrations were also lowered (by 46%, 34%, and 17%, respectively), while diuresis was increased by 107%. Immersion at 20°C induced a similar decrease in plasma renin activity, heart rate and systolic and diastolic blood pressures as immersion at thermoneutrality, in spite of lowered rectal temperature and an increased metabolic rate by 93%. Plasma cortisol concentrations tended to decrease, while plasma aldosterone concentration was unchanged. Diuresis was increased by 89%. No significant differences in changes in diuresis, plasma renin activity and aldosterone concentration compared to subjects immersed to 32°C were observed. Cold water immersion (14°C) lowered rectal temperature and increased metabolic rate (by 350%), heart rate

and systolic and diastolic blood pressure (by 5%, 7%, and 8%, respectively). Plasma noradrenaline and dopamine concentrations were increased by 530% and by 250% respectively, while diuresis increased by 163% (more than at 32°C). Plasma aldosterone concentrations increased by 23%. Plasma renin activity was reduced as during immersion in water at the highest temperature. Cortisol concentrations tended to decrease. Plasma adrenaline concentrations remained unchanged. Changes in plasma renin activity were not related to changes in aldosterone concentrations. Immersion in water of different temperatures did not increase blood concentrations of cortisol. There was no correlation between changes in rectal temperature and changes in hormone production. Our data supported the hypothesis that physiological changes induced by water immersion are mediated by humoral control mechanisms, while responses induced by cold are mainly due to increased activity of the sympathetic nervous system.

Key words Cold water immersion · Cardiovascular functions · Catecholamines · Plasma renin activity · Cortisol

P. Šrámek · M. Šimečková
Faculty of Physical Education and Sports,
University Hospital,
Charles University,
Prague, Czech Republic

L. Janský (✉) · S. Vybíral
Department of Comparative Physiology,
Faculty of Science, Charles University 128 00 Prague 2,
Viničná 7, Czech Republic
Tel.: + +42-2-21953247, Fax: + +42-2-299713

J. Šavlíková
2nd Department of Internal Medicine,
University Hospital,
Charles University,
Prague, Czech Republic

Introduction

Immersion in cold water may exert its influence on the human body by both stimulation of baro- and cold receptors and by activation of the sympathetic nervous system and endocrine function. These responses may in turn influence mechanisms controlling cardiovascular function and water balance.

It has been shown repeatedly that immersion into thermoneutral water increases central blood volume (Arborelius et al. 1972; Epstein et al. 1981), mean stroke volume and, consequently, mean cardiac output, whereas systemic vascular resistance has been shown to decrease (Arborelius et al. 1972; Echt et al. 1974). Changes in blood pressure induced by immersion are not uniform. Most investigators have failed to observe