Changes in heart rate during a headstand while in water

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Introduction

During water exercise, it has been established that heart rate (HR), oxygen uptake, and body temperature respond to the effects of water pressure, temperature, buoyancy and viscosity. Previous studies have demonstrated these responses differed from those on land.

Figure. Changes in oxygen uptake between land and Water conditions
Water temperature : 30°C, room temperature : 30°C, walking time : 15min., walking speed : 4km/h
(Onodera et al., J.J. Aerospace ENV. MED, 1992)
Introduction

Previous studies showed that HR significantly decreased during standing in water, and that the decreased HR depended on the depth of immersion.

*Figure* - Heart rate kinetics at each condition of water depth. A: on land, B: knee joint, C: greater trochanter, D: xiphoid process, E: under the collarbone. ANOVA; *p*<0.05, **p**<0.05, vs A condition (base), ###; *p*<0.05
Introduction

Another previous study established a relationship between HR and body posture. HR significantly decreased during standing in water.

A headstand posture is often assumed during synchronized swimming at swimming competitions.

However, it remains uncertain whether changes in HR during in a headstand position in water are the same as those while in a standing position.
Hypothesize

HR would decrease during a headstand while in water.

Purpose

The aim was to determine the changes in HR during a headstand posture during in water.
Methods

Ten healthy Japanese male volunteers

mean age : 23 ± 3 years
mean height : 173 ± 6 cm
mean body weight : 70 ± 6 kg

This study was approved by the Ethics Committee of Kawasaki University of Medical Welfare (Japan).
None of the subjects smoked or had medical histories, including metabolic diseases, which may have affected the cardiovascular system.
Methods

Each subject performed a headstand for one minute under each condition.

Two conditions: A, headstand on land;
B, headstand in water.

in water condition, each subject breathed through a compressed gas cylinder used for scuba diving.

Water depth was set at the waist (navel) level during standing in water, and the same water depth was used during a headstand.
Methods

Figure. headstand in water
Methods

Water temperature  30°C
Room temperature  28°C

HR was continuously measured using a waterproof HR monitor (MemCalc/Bonaly Light; BMS, Japan).

The response of heart rate was analyzed by two-way (condition × time) ANOVA of repeated measures.

Statistical significance level was set at $p<0.05$.
The data was analyzed by SPSS ver. 12.0 for Windows.
Figure. Changes in heart rate in the headstand position on land (condition A: ■) and in water (condition B: □). Values are means ± SD's. * significant difference between condition A and condition B; p < 0.05.
Results

HR rapidly decreased within 24 s from the beginning of a headstand posture in water (condition B) and subsequently maintained a steady-state level.

The changes in HR while in water (condition B) were statistically significant (by ANOVA, p < 0.05).
Discussion

A decreased HR during water immersion is primarily due to the greater venous return-associated increase in cardiac output.

These responses could occur within approximately 20 seconds after immersion, and a delay in observing this response could depend on the water level. We consider the time order for the changes in HR that we observed agreed with that in a previous study.

The changes in HR until 18 seconds followed a similar time course with both conditions. Therefore, we consider that a decrease in HR until 18 seconds was caused by the change in posture and those changes after 18 seconds were caused by the acceleration of venous return.
Figure. Comparison of the cross sectional area of inferior vena cava between on land condition and in water condition using a B-mode echocardiography.

○: inferior vena cava

Figure. Changes in cross area of inferior vena cava in different water depths. C-condition, out of water, T-condition, trochanter major, P-condition, processus xiphoidens, A-condition, axilla. Values are means ± SD. *p<0.05 compared with control.

Figure. Changes in heart rate in the headstand position on land (condition A: ■) and in water (condition B: □).
Values are means ± SD’s. *significant difference between condition A and condition B; p < 0.05.
Discussion

Diving reflex

HR in men decreased until approximately 60 seconds during apnea with immersion in water. However, in the present study, HR remained a plateau after 30s under condition B. We consider that our subjects were affected by breathing through a compressed gas cylinder used scuba in the water.
Discussion

Exercise intensity

A change in load weight could also depend on the water level. According to Archimedes' principle, when the water level is increased, body buoyancy is increased.

This suggests that exercise intensity was very low during condition B, and that the change in venous return volume could maintain this acceleration.
Conclusion

Our results showed that HR decreased during a headstand in water, which could be attributed to the diving reflex and an increase in venous return.
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