Changes in urine volume and subjective micturition during a sitting posture while in water

Wada Takuma¹, Hayashi Sotaro¹, Nose Yuka², Michael J. Kremenik³, Onodera Sho³

¹) Graduate School, Kawasaki University of Medical Welfare
²) Yasuda Women’s University
³) Kawasaki University of Medical Welfare
Previous studies have demonstrated that physiological responses while in water differ from those while on land due to the physical characteristics of water.

(Onodera et al, J Phys Fitness Sports Med, 2013)

Fig. Changes of heart rate during standing in water

<table>
<thead>
<tr>
<th></th>
<th>Land</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Heart rate ( bpm )</td>
<td>Heart rate ( bpm )</td>
</tr>
<tr>
<td>Time ( min. )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young</td>
<td>60±10.8</td>
<td>58±10.4</td>
</tr>
<tr>
<td>(n=9)</td>
<td>59±9.5</td>
<td>57±9.6</td>
</tr>
<tr>
<td></td>
<td>57±8.3</td>
<td>56±8.2</td>
</tr>
<tr>
<td></td>
<td>60±9.5</td>
<td>57±7.3</td>
</tr>
<tr>
<td>Elderly</td>
<td>70±14.1</td>
<td>65±10.4</td>
</tr>
<tr>
<td>(n=13)</td>
<td>67±12.1</td>
<td>64±8.8</td>
</tr>
<tr>
<td></td>
<td>68±8.0</td>
<td>61±6.4</td>
</tr>
<tr>
<td></td>
<td>66±9.3</td>
<td>64±9.3</td>
</tr>
</tbody>
</table>

(Onodera et al, J Phys Fitness Sports Med, 2013)

Fig. 1 Time course of changes in oxygen consumption (upper panel) and rectal temperature (lower panel) of subjects resting in water. Data represent the mean of 12 subjects.

(Choi, JS et al, Appl human sci, 1996)
Venous return and urine formation increases while in water, after which a diuretic effect increases. 

(Greenleaf et al., J. appl. Physiol, 1980)

Compared with land exercise, the loss of body fluid in water exercise increases due to urine.

(Nagashima et al., J. appl. Physiol, 1995)

- Kidney blood flow
- Atrial natriuretic peptide
- Plasma renin activity
- Aldosterone

Increase in urine volume

### Table. Changes in urine volume per a minute (UV)

<table>
<thead>
<tr>
<th></th>
<th>Swimming club members</th>
<th>Males</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before water immersion</td>
<td>0.9 ± 0.3</td>
<td>0.8 ± 0.1</td>
</tr>
<tr>
<td>During water immersion</td>
<td>2.4 ± 1.4</td>
<td>3.5 ± 1.6</td>
</tr>
<tr>
<td>After water immersion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0~30)</td>
<td>2.2 ± 0.8</td>
<td>3.1 ± 1.1</td>
</tr>
<tr>
<td>(30~90)</td>
<td>1.3 ± 0.4</td>
<td>1.6 ± 0.3</td>
</tr>
<tr>
<td>(90~150)</td>
<td>1.0 ± 0.1</td>
<td>1.1 ± 0.2</td>
</tr>
</tbody>
</table>

*(Kasugai et al, Bull. Health & Sport Sciences, University of Tsukuba, 1990.)*
The purpose of this study was to investigate the relationships between urine volume, subjective micturition, reported thermal sensation, heart rate, skin temperature, blood pressure and rectal temperature while in a sitting posture in water.
Subjects

Eight Japanese healthy males

Table 1. Physical characteristic of subjects

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Height (cm)</th>
<th>Body weight (kg)</th>
<th>Body fat (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>21.3 ± 0.9</td>
<td>167.8 ± 4.5</td>
<td>69.1 ± 6.5</td>
<td>14.3 ± 3.3</td>
</tr>
</tbody>
</table>

(mean ± SD)

Environmental conditions

Table 2. Environmental temperature at measurement point

<table>
<thead>
<tr>
<th>Water temperature (°C)</th>
<th>temperature (°C)</th>
<th>Relative humidity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30.2 ± 0.3</td>
<td>28.9 ± 0.3</td>
<td>56.7 ± 4.4</td>
</tr>
</tbody>
</table>

(mean ± SD)
Measurement conditions

★ Land condition (L)

★ Water condition (W)
Measurement items

- Urine volume
- Subjective micturition (VAS)
- Reported thermal sensation
- Heart rate (HR; RS400; POLAR)

- Skin temperature
- Blood pressure (SBP, DBP)
- Rectal temperature
Experiment protocol

On land

30min | 30min | 30min | 30min

Rest | In water | Recovery

C

W

30min | 30min | 30min | 30min

Urine

Urine volume, Subjective micturition, Skin temperature

Heart rate, Reported thermal sensation (every 5 min)

Rectal temperature, Blood pressure (every 10 min)
Fig1. Comparison of the urine volume between W and C condition

* C vs. W p < 0.05
Fig2. Comparison of the subjective micturition between W and C condition

* C vs. W p < 0.05
Fig3. Comparison of the heart rate between W and C condition

* C vs. W p < 0.05
Fig4. Comparison of the reported thermal sensation between W and C condition

* C vs. W p < 0.05
Fig5. Comparison of the rectal temperature between W and C condition

* C vs. W p < 0.05
Fig 6. Comparison of the skin temperature between W and C condition

* C vs. W p < 0.05
Fig7. Comparison of the blood pressure (SBP) between W and C condition

* C vs. W p < 0.05
Fig7. Comparison of the blood pressure (DBP) between W and C condition

* C vs. W p < 0.05
While in water, venous return in the body increases due to the water pressure and the stroke volume and HR are decreased.

(Onodera et al, J Phys Fitness Sports Med, 2013)

Venous return increases due to the water level.

(Onodera et al, J Phys Fitness Sports Med, 2013)

The stroke volume significantly increases when the water level reaches the level of the xiphoid process.

(Onodera et al, J Phys Fitness Sports Med, 2013)

HR while in water resting conditions were lower as than those on land resting conditions, a result which was in agreement with a previous report.
The thermal conductivity of water is approximately 25 times higher than that of air.

(Onodera et al, J Phys Fitness Sports Med, 2013)

In this range of water temperature, the rectal temperature is lower because the thermal conductivity of water is high.

(Onodera et al, J Phys Fitness Sports Med, 2013)

We previously reported that water temperature had an effect on temperature changes in humans within a short time.

(Rabelink et al American Journal of Physiology, 1989)

The increase reported thermal sensation increased a subjective micturition.
The thermal conductivity of water is approximately 25 times higher than that of air.

(Onodera et al, J Phys Fitness Sports Med, 2013)

In this range of water temperature, the rectal temperature is lower because the thermal conductivity of water is high.

The inundation increased a urine volume and subjective micturition.

The increase reported thermal sensation increased a subjective micturition.
✓ Urine volume and subjective micturition increases through inundation in water.

✓ Urine volume decreases with progress at each time of recovery.

✓ The decrease in urine volume at the time of recovery links to a subjective micturition.
Changes in urine volume and subjective micturition during a sitting posture while in water

Wada Takuma¹, Hayashi Sotaro¹, Nose Yuka², Michael J. Kremenik³, Onodera Sho³

1) Graduate School, Kawasaki University of Medical Welfare
2) Yasuda Women’s University
3) Kawasaki University of Medical Welfare