Difference of Physiological Responses to Swimming and Running

Hideki HARA*, Hiroyuki TANAKA** and Kumiko MINATO***

*Department of Health and Physical Education, Kokugakuin University
**Faculty of Living and Health Science, Naruto University of Education
***Wayo Women’s University

The purpose of this research is to investigate the range of response to the treadmill running and swimming. Cardiovascular changes and substrates changes in blood were examined before and after healthy male subjects (swimming group (SG) has swimming habits and running group (RG) has practiced basketball or baseball or running more than four days a week) swam and ran for 10 to 15 minutes voluntarily. Average heart rate was recovered more quickly in case of running than swimming in the RG, but in the SG there was no difference. Diastolic blood pressure recovered to the rest condition faster in the SG than RG. In case that subjects have done familiar exercise, free fatty acids increased a little more after 10 minutes than in case of unfamiliar exercise.

These results suggest that response of habitual exercise showed lesser change of diastolic blood pressure and more increase of free fatty acids. There might be a difference in physiological responses between usual sports and other kinds, so that we had to be careful when we apply different styles of activity to use training. (Ann. Physiol. Anthrop. 11(3) : 295-299, 1992)

Key words: Habitual exercise, Running, Swimming, Heart rate, Free fatty acids

To keep homeostasis, physical exercise is necessary for man in some strength (Saltin, 1968 and Taylor, 1949) and some duration using energy which stored in muscles and other kinds of internal organs (Costill, 1977). In our daily life, we can move by means of these muscle contraction (Keul, 1974 and Thomas, 1977). And it is generally known that physiological reactions for these exercises are different to running, cycling and swimming and other sports (Holmer and Lundin, 1974). Especially exercise in water presents very large difference to exercise on land (Holmer and Stein, 1974), because of the heat loss (Holmer and Bergh, 1974 and Rennie, 1974), pressure and resistance from water and body posture, further more those who has not been done in water as the custom of life.

One of the goals of physiological activities is to maintain his condition, so he needs not work hard as to maximum oxygen uptake (VO₂max) or maximum heart rate (HRmax) like competitive athletes. In these case, exercise strength was controlled by respiratory rhythm and perception of hardness like the Rate of Perceived Exertion. Generally, competitive runners and swimmers are training in order to advance their performances. Setting practice schedule for these athletes are by the professional coaches or trainers such as time and distance for each athlete. But ordinary man dose his work on ones' own sense of exercise who practiced not for the progress of their records but for the health. For example, running velocity is not so high that keep endurance practice about from forty to eighty percent of his maximum ability. General man can keep these pace of speed more than ten minutes longer easily without hardness. Like these strength of training would change energy metabolism for
mild exercise. Exercise in water need more energy than on land if moving the same distances. And experiment in water has many difficulties so that reactions of physiological aspects have not known than exercise on land. Holmer (1974) reported that \( \dot{V}O_2 \) max while swimming was less than running by tethered swimming. But no one compared to swimming and running at self selected pace.

The purpose of this study is to know difference between swimming and running at self selected pace of speed.

**METHODS**

Subjects were healthy male, aged 18 to 28 years, who were accustomed to physical activities such as basketball, baseball, running and swimming more than four days a week. They were given explanation about the purpose of this research and voluntary attended measurements. The S Group members aged 20.8 years (mean)\( \pm \)3.1 (SD) were consisted of competitive swimming and water polo club members of a college and of another swimming club members. The R Group members aged 20.4 years (mean)\( \pm \)1.2 (SD) joined baseball or basketball or ski club.

**Table 1** Characteristics of subjects

<table>
<thead>
<tr>
<th></th>
<th>age (yrs)</th>
<th>height (cm)</th>
<th>weight (kg)</th>
<th>fat percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Running Mean group</td>
<td>20.4</td>
<td>169.02</td>
<td>64.74</td>
<td>12.334</td>
</tr>
<tr>
<td></td>
<td>S.D</td>
<td>1.2</td>
<td>4.49</td>
<td>2.548</td>
</tr>
<tr>
<td>Swimming Mean group</td>
<td>20.8</td>
<td>169.01</td>
<td>65.98</td>
<td>12.051</td>
</tr>
<tr>
<td></td>
<td>S.D</td>
<td>3.1</td>
<td>5.40</td>
<td>6.14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.037</td>
</tr>
</tbody>
</table>

The first protocol was fifteen minutes treadmill running, and the second was about ten minutes swimming in the fifty meters pool. The running speed determined 180 m/min because in the pre-exercise test, all subjects tried and kept steady state on this speed at fast. On the other hand, swimming speed could not be decided at one velocity, so that every subject swam at steady speed all through the distance more than ten minutes.

In the running experiment, heart rate (HR) were monitored with bipolar ECG telemetry system from the rest condition before treadmill running to thirty minutes after the end of running in recovery condition. In the swimming experiment, HR was measured before swimming and after exercise to thirty minutes of recovery condition as same as running protocol with ECG. Blood pressure (BP) measured at rest and two minutes after exercise, five, ten and thirty. Blood sampling were from cubital vein at rest and immediately, ten and thirty minutes after exercise.

Glucose in Blood was analyzed by two wavelength automatical analyzers (ABA-100) and free fatty acids (FFA) in blood extracted by Folch methods (Folch, 1957) and isolated by thin-layer chromatography then which was analyzed to saturated and unsaturated FFA with gas chromatography (JGC-20KP).

**RESULTS**

In case of swimming, subjects were told to swim at the same speed, but in fact, they swam 42.8 m/min (mean)\( \pm \)2.9(SD) in RG and 59.2 m/min (mean)\( \pm \)6.4 (SD) in SG.

**Table 2** The speed of 10 min. swimming(m/min.) (mean\( \pm \)SD)

<table>
<thead>
<tr>
<th></th>
<th>Running G.</th>
<th>Swimming G.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>42.83</td>
<td>59.18</td>
</tr>
<tr>
<td></td>
<td>( \pm )2.88</td>
<td>( \pm )6.40</td>
</tr>
</tbody>
</table>

The HR data are shown in Fig. 1. The HR of the RG after swimming was 9.7beats/min (mean) higher than that of the SG, and after running the HR of SG was 3.6beats/min higher than the RG 2 minutes after exercise.

Systolic blood pressure did not indicate any difference with not only RG and SG but also swimming and running in the same group. On the other hand,
diastolic blood pressure in the RG after swimming was lower than that after running (Fig. 2).

In the RG, FFA value increased from 285.73 μEq/L (mean) immediately after running to 566.09 μEq/L (mean) at 10 minutes after exercise and the difference was 280.36 μEq/l, which was about 98% increase. After swimming, FFA increased from 232.52 μEq/l to 324.99 μEq/l and the difference was 92.74 μEq/l, that was only 39%. In the SG, after running FFA showed 108% rise, that is, from 224.82 μEq/l to 468.99 μEq/l (difference was 244.17 μEq/l), and after swimming it was from 300.42 μEq/l to 462.

**Table 3** The value and rate of increase in FFA from immediately to 10min. after exercise

<table>
<thead>
<tr>
<th>Group</th>
<th>Running</th>
<th>Swimming</th>
</tr>
</thead>
<tbody>
<tr>
<td>Running TSF</td>
<td>88.09 μEq/L</td>
<td>91.00 μEq/L</td>
</tr>
<tr>
<td>TUF</td>
<td>129.25 μEq/L</td>
<td>123.99 μEq/L</td>
</tr>
<tr>
<td>Total</td>
<td>280.36 μEq/L</td>
<td>244.17 μEq/L</td>
</tr>
<tr>
<td>Swimming TSF</td>
<td>39.36 μEq/L</td>
<td>57.64 μEq/L</td>
</tr>
<tr>
<td>TUF</td>
<td>51.92 μEq/L</td>
<td>104.93 μEq/L</td>
</tr>
<tr>
<td>Total</td>
<td>91.27 μEq/L</td>
<td>162.57 μEq/L</td>
</tr>
</tbody>
</table>

TSF: total saturated fatty acids
TUF: total unsaturated fatty acids
98 μEq/l, 162.56 μEq/l and the rate of increase was 54%.

Glucose increased after running more than that after swimming in the RG but in the SG, glucose increased after running fewer than swimming.

**DISCUSSION**

In a daily life, ordinary people have to be walk more or less, but some of them need not run, and only a few swim. The subjects of this study were exercising almost every day of their respective sports. The physiological reactions to the habitual exercises might be matured during a long time experience. Running in the running group (RG) and swimming in the swimming group (SG) were so familiar to them that metabolic adaptation for these strength of practise must be easy. HR responses to the exercises revealed familiarity of the subjects to their own sports. In case of running, HR of RG was lower than that of SG, but on the other hand, after swimming, HR of SG was lower than that of RG. But the hardness of unfamiliar style of exercise are shown in diastolic blood pressure. Diastolic blood pressure in RG after swimming dropped remarkably.

Carlson (1961, 1980) and Tsutsumi (1971, 1972) reported even though physical intensity was same, in case of HR response would be different, FFA response might be different. In this case, the rate of FFA increase from immediately after exercise to ten minutes was higher in the daily practised kinds of sports than other. Hagenfelbdt (1975) described that FFA release from organ exceed FFA intake to muscle, that is same as the increase of FFA from immediately after exercise to ten minutes. Total FFA constructed from saturated and unsaturated fatty acids (Nakamura, 1976). It is important from the view point of FFA oxidation that unsaturated state seemed effective for β-oxidation as energy. The results of this study as FFA increase in habitual exercise suggested effective use of FFA in sports habitually practiced.

**REFERENCES**


(Received March 5, 1992)

Hideki HARA
Kokugakuin University Health and Physical Education
Higashi 4-10-28 Shibuya-ku, Tokyo, Japan, 150

原 英喜
〒150 東京都渋谷区東4-10-28 国学院大学 保健体育学研究室