Physical Fitness Assessment by Using Heart Rate and Physical Activity Sensor

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Abstract - Physical fitness is an important health indicator. Assessment of physical fitness can provide information on chronic diseases or athletes’ training. A heart rate and activities monitoring sensor has been developed to predict physical fitness. The embedded algorithm is based on data collection from heart rate and movement index during the experiment. Comparable data sets have been described with the prediction model. The experiment protocols are based on laboratory test.

Keywords: Fitness assessment, heart rate, physical activities, prediction model

1 Introduction

Physical fitness has been defined in many ways. Health-related physical fitness includes cardiorespiratory endurance, muscular strength, and flexibility. The health-related fitness is strongly associated with the risk of chronic diseases [1], cardiovascular diseases, and metabolic syndrome [2]. Performance-related fitness refers to adequate athletic performance and encompasses components such as power, strength, speed-agility and balance [3]. The coach can select elite athletes through endurance fitness test, which could save the public resources and time.

Assessment of fitness can also optimize the training protocol by taking different physical characteristics of athletes into account. The maximal oxygen uptake (VO₂max) has been recommended as the reference value for fitness assessment. Variety of non-exercise models have been developed for the estimation of VO₂max. However, most of these models depend on self-reported physical activities, which are effective for use in large epidemiological cohorts [4]. For individual patient or athlete, these models would be impractical. The maximal and submaximal exercise test for the assessment of cardiorespiratory fitness in the general public is well recognized. In this study, the fitness is assessed from the experiment test based on heart rate and physical activities monitoring using chest-patch-type sensor.

2 Heart rate and activity monitoring sensor

Our works developed a suitable and high accuracy method for heart rate monitoring in an environment with harsh conditions, and a new indicator that correlates well with conventional movement index. The small, lightweight, patched-type sensor module can collect vital information related to health conditions of the subject in real-time, as shown in Fig. 1.

Fig. 1. Displayed heart rate and movement index.

The system, which we call as AirBeat, includes one patch-type sensor (middle), a wireless communication module (left), and portable devices (right), as shown in Fig. 2. The sensor node comprises a tri-angular chip integrated with the ECG electrode, a ZigBee RF communication module, a micro-controller, and a 3-axis accelerometer sensor. The top bottom, packed with battery and silicon covered sensor node. The heart rate and movement index are monitored in real time during the experiment. The data are collected to estimate VO₂max.
3 Method and experiments

The experiments are based on laboratory. Five male participants, with ages 27 and 28 years, ran on the treadmill machine at speeds that ranged from 0.2 km/h to 13 km/h. The speed was increased gradually as shown in Table 1. The participants started by walking and then ran till they were exhausted. The sensor was patched on the chest to collect the heart rate and movement index data. Participants were made to wear an indirect calorimeter for receiving the standard measured \( \text{VO}_{2\text{max}} \).

<table>
<thead>
<tr>
<th>Step</th>
<th>Duration (second)</th>
<th>Speed (km/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0 – 60</td>
<td>0.2</td>
</tr>
<tr>
<td>2</td>
<td>60 – 180</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>180 – 300</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>300 – 600</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>600 – 780</td>
<td>13</td>
</tr>
</tbody>
</table>

Heart rate and movement index were combined to estimate \( \text{VO}_{2\text{max}} \). The values of heart rate and movement index increased linearly during the experiment. Although the heart rate and \( \text{VO}_{2\text{max}} \) reached their maximal values, the movement index constantly increased with time. Therefore, we can determine \( \text{VO}_{2\text{max}} \) based on the linear relationship, and the maximal heart rate can be a domain of variance.

4 Results

Heart rate and movement index increased with steady slopes until the heart rate reached its maximal value, beyond which it does not increase. The oxygen consumption also reached its maximal value, as shown in Fig. 3. \( \text{VO}_{2\text{max}} \) can be finally measured.

5 Conclusion

We identified the method of physical fitness assessment by using a heart rate and activity sensor. The \( \text{VO}_{2\text{max}} \) was estimated based on the submaximal protocol in the laboratory environment. In future study, non-exercise \( \text{VO}_{2\text{max}} \) prediction models will be developed by various parameters, such as body weight. Regression equations can then be derived for enhanced accuracy.

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References


