Aerobic Work Capacity Measurements and Evaluations on students specialized in Nursing using Ergometer

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The purposes of this study were to measure and evaluate an aerobic work capacity on students specialized in nursing using an ergometer and to study a needs of physical activity classes from viewpoint of the nursing management (Administration) in the nursing education. To perform these purposes, 152 students of VO2max and PWC75%HRmax as an index of an aerobic work capacity were measured using an ergometer. VO2max was estimated by the relationship between VO2 and heart rate (HR) in each subject in the incremental exercise (20W/min) test using a bicycle ergometer. VO2max was decided as the VO2 in predicted HRmax in each subject. HRmax was decided by means of the following calculation "HRmax = 220 - age".

Average of VO2max and VO2max/Wt of 152 subjects were 2.0l/min (SD=0.38) and 39.0ml/kg/min (SD=5.16), respectively. Average of PWC75%HRmax and PWC75%HRmax/Wt were 108.5W (SD=24.35) and 2.1W (SD=0.36), respectively. Moreover, the relationship between VO2max and PWC75%HRmax was Y = 11.59X - 16.94. VO2max of this subject was 33.2ml/kg/min.

PWC75%HRmax was determined by the relationship between HR and exercise work load in the above-mentioned incremental exercise test. A subject of the relationship between HR and exercise work load was Y = 0.25X - 16.94. PWC75%HRmax of this subject was 109.3W.

Average of VO2max and VO2max/Wt of 152 subjects were 2.0l/min (SD=0.38) and 39.0ml/kg/min (SD=5.16), respectively. Average of PWC75%HRmax and PWC75%HRmax/Wt were 108.5W (SD=24.35) and 2.1W (SD=0.36), respectively. Moreover, the relationship between VO2max and PWC75%HRmax was Y = 11.59X - 16.94. VO2max of this subject was 33.2ml/kg/min.

Based on previous studies, an average energy expenditure in nursing work (5.0 METs) was estimated to almost 3.1 times of that in office working (1.6 METs). This level of a work load in nursing work was almost equal to anaerobic threshold (AT) level in the subjects of the present study.

AT was thought to be related to the blood lactate production and the capacity of its oxidization. A continuous high blood lactate beyond AT level might be reduced a working efficiency in nursing. In addition, the higher PWC75%HRmax was, the more efficient work could be performed in spite of same physical condition. It was suggested that to be high PWC75%HRmax was advantage for the nursing work. Consequently, an aerobic work capacity measurement and evaluation was thought to be important for the nursing education from point of the nursing management, and a needs of the physical activities classes in the nursing education was suggested.

Introduction

With increasing in aging patients and diversification of diseases, a work load of nursing has increased because a duty in nursing has become to be much. In the previous studies, work loads of nursing from various viewpoint points were investigated.

Shimoyama et al. (1996) reported the relationship between the ratio of a perceived busyness and an actual busyness, and the factors which had influenced on the ratio of a perceived busyness. They suggested in this report that the investigation of the ratio of a perceived busyness in a ward was useful for the nursing management (Administration). Takahashi et al. (1997) investigated the quality of a nursing work and reported over 30% of nursing work was a care of patients. Sato et al. (1996) reported that an aging nurses did not take a rest in nursing in spite they felt to be tired. On this report, they developed the index of taking a rest in nursing. Similarly, Tanji et al. (1995) analyzed the factors related with a fatigue of a nurse and attempted to develop the check list for a perceived fatigue.

Based on the previous studies both the physical and mental work load are very important for the nursing management (Ichikawa et al., 1996; Mizuno et al.,1997).

These investigations, however, were conducted in the field survey, an experimental investigations about a work load especially physical work load in nursing were very few. One of some reasons to this was thought that physical (Activity) education and its
understanding (Involving in a needs of physical activities classes) in the nursing education was not always complete.

The purposes of this study were to measure and evaluate an aerobic work capacity on students specialized in nursing using an ergometer and to study a needs of physical activities classes in the nursing education especially from view point of the nursing management.

Method

To perform the above-mentioned purposes, VO$_{2\text{max}}$ and PWC$_{75\%HR_{\text{max}}}$ as an index of an aerobic work capacity of 152 female students as a subject specialized in nursing were measured. VO$_{2\text{max}}$ and PWC$_{75\%HR_{\text{max}}}$ measurements were done in the physical education classes in the curriculum of the nursing.

Each subject wore the mask, for sampling of an expire gas, connected to the energy metabolism measurement system (Sensor Medicks MMc4400tc: EMMS). After driving ergometer at 0W as a warming up, each subject conducted the 1-min incremental exercise (20W/min) test using a bicycle ergometer (Takei Coop. Iso-power Ergometer). VO$_2$, VCO$_2$, VE, ETO$_2$, ETCO$_2$ and R (VCO$_2$/VO$_2$) in each subject were measured by breath-by-breath expire gas exchange analysis using EMMS and synchronized with an exercise work load input from the ergometer. In addition, because EMMS could not measure heart rate (HR), HR was measured by ECG (Nippon Koden Coop.). HR calculated from ECG was input into EMMS, synchronized to the above-mentioned ventilation parameters.

In order to keep a physical safety in each subject and to shorten a measurement time in each subject, measurement was stopped when HR in each subject was around 150bpm.

VO$_{2\text{max}}$ was estimated from the relationship between VO$_2$ and HR in each subject in this incremental exercise test (Fig.1). VO$_{2\text{max}}$ was decided as the VO$_2$ in predicted HR$_{\text{max}}$ in each subject. HR$_{\text{max}}$ was determined by equation of the following "HR$_{\text{max}} = 220 - \text{age}".

PWC$_{75\%HR_{\text{max}}}$ was determined from the relationship between HR and exercise work load in the above-mentioned incremental exercise test (Fig.2). PWC$_{75\%HR_{\text{max}}}$ was evaluated as a work load in 75% of HR$_{\text{max}}$ ( =220-age ). If subject was 20 years old, 75% of HR$_{\text{max}}$ was as follows; (220 - 20) * 0.75 = 150 [bpm].

Results

Fig.1 shows the relationship between VO$_2$ and HR in the incremental exercise test in a single subject. The relationship was $Y = 0.25X - 16.94$. Estimated VO$_{2\text{max}}$ calculated by above-mentioned procedure was 33.2ml/kg/min.

Fig.2 shows same subject of the relationship between HR and exercise work load in the incremental work load exercise test. The relationship was $Y = 0.534X - 91.62$. PWC$_{75\%HR_{\text{max}}}$ calculated by above-mentioned procedure was 109.3W.

Table.1 shows averages of VO$_{2\text{max}}$ and PWC$_{75\%HR_{\text{max}}}$ of 152 subject. Average of VO$_{2\text{max}}$ was 2.0l/min (SD=0.38) and VO$_{2\text{max}}$/Weight (Wt) was 39.0ml/kg/min (SD=5.16). Average of PWC$_{75\%HR_{\text{max}}}$ was 108.5W (SD=24.35) and PWC$_{75\%HR_{\text{max}}}$/Wt was 2.1W/kg (SD=0.36).

Fig.3 shows the relationship between VO$_{2\text{max}}$ and PWC$_{75\%HR_{\text{max}}}$. The relationship was $Y = 11.593X + 14.78$ ( $p<0.001$ ) and high significant statistically.

Discussion

The nursing managements have been studied from various view points. Many of these studies have been conducted in the field survey, for examples of a work load in nursing, a fatigue in nursing, a motivation for nursing, a mental health in nursing and so on. A work environment or management in nursing as it ought to be based on these studies has been proposed. As mentioned-above, however, experimental investigations about physical work load in nursing were very few.

Takahashi et al. (1997) reported that high frequent works in ordinary nursing in a ward were cares of patients and supports of medical treatments. They accounted almost 50% for all work in nursing.
Fig. 1 The relationship between VO\textsubscript{2} and HR

Table 1. Average of physical characteristics of subject

<table>
<thead>
<tr>
<th>Items</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>VO\textsubscript{2max} (l/min)</th>
<th>VO\textsubscript{2max}/Wt (ml/kg/min)</th>
<th>PWC\textsubscript{75%HRmax} (Watt)</th>
<th>PWC/Wt (Watt/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>158.0</td>
<td>51.2</td>
<td>2.1</td>
<td>39.0</td>
<td>108.5</td>
<td>2.1</td>
</tr>
<tr>
<td>S.D.</td>
<td>4.31</td>
<td>5.60</td>
<td>0.38</td>
<td>5.16</td>
<td>24.35</td>
<td>0.36</td>
</tr>
<tr>
<td>Minimum</td>
<td>148.0</td>
<td>42.0</td>
<td>1.2</td>
<td>27.5</td>
<td>75.0</td>
<td>1.2</td>
</tr>
<tr>
<td>Maximum</td>
<td>168.0</td>
<td>70.0</td>
<td>3.2</td>
<td>54.8</td>
<td>171.8</td>
<td>3.1</td>
</tr>
<tr>
<td>Range</td>
<td>20.0</td>
<td>5.60</td>
<td>2.00</td>
<td>27.30</td>
<td>99.8</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Fig. 2 The relationship between HR and work load

Fig. 3 The relationship between VO\textsubscript{2max} and PWC\textsubscript{75%HRmax}

Fig. 4 The comparison PWC\textsubscript{75%HRmax} of 3 subjects
Omura et al. (1997) reported the EMG activity on the lower back in nursing was 3.1 times than office working.

In general, an energy consumption in office working has been reported to be 1.6 Kcal/kg/h on an average (Nakamura et al. 1976). This energy consumption is equal to 1.6 METs, and VO$_2$ of 5.7 ml/kg/min (1.0 Kcal/kg/h = 1 MET = 3.5 ml/kg/min). If energy consumption in nursing is 3.1 times than office working too, METs and VO$_2$ in nursing are 5.0 METs and 17.6 ml/kg/min respectively.

Regarding the relationship between VO$_2$ and HR shown in Fig.2, VO$_2$ of 17.6 ml/kg/min corresponds to 137bpm of HR. 137bpm of HR is in 37.0 ages in accordance with PWC75%HRmax calculation procedure, and 137bpm of HR in 37.0 age is thought to be almost AT (Anaerobic Threshold) level (Nemoto et al., 1980; Miyashita et al., 1988). Additionally, 137bpm of HR is equal to 85.0 W of the work load.

It has been thought that AT has been related to blood lactate production and a capacity of its oxidization (Shionoya et al., 1996). A continuous high density of blood lactate beyond AT level might be reduced a working efficiency in nursing. Tamura et al. (1989) measured AT of healthy adults, top swimmers and cardiac disease patients and suggested that AT was an index which reflected the physical activity level in daily life. As above-mentioned, Takahashi et al. (1997) reported that high frequent works in ordinary nursing in a ward were cares of patients and supports of medical treatments. They contained a high load work such as a body position exchange of a critical disease patient. When a nurse has a high AT, she would be able to sustain continuously high load works such as body position exchanges (Tamura et al., 1989). Fig.4 shows the relationships between HR and exercise work load, and PWC75%HRmax of 3 subjects in this study. Subject denoted as □ was same in Fig.3. PWC75%HRmax of subject denoted as □ was 89.56W. As same, PWC75%HRmax of subject denoted as □ was 118.37W. It is advantage for nursing to have a high PWC75%HRmax. Because the higher PWC75%HRmax is, the more work can be performed in spite of same physical condition (HR) as shown in Fig.4.

Consequently, an aerobic work capacity measurement and evaluation such as PWC75%HRmax or VO$_2$max and VO$_2$max/Wt are evaluated to be good as young female subjects. Additionally, VO$_2$max was 2.0l/min and VO$_2$max/Wt was 39.0ml/kg/min, these have been good too.

Although both average of VO$_2$max and PWC75%HRmax is scored as good, individual evaluation for each subject is also important. Miyashita et al. (1984) developed the 6 stages measure for evaluation of an aerobic work capacity, which PWC75%HRmax below 79.0W and VO$_2$max/Wt below 31.4ml/kg/min have been evaluated as poor. The poor area of VO$_2$max/Wt is shown in Fig.3. Students in this area need to be educated from point of the physical activities classes.

### Notes

Measurements and evaluations in this study were done as curriculums of the physical activities classes in nursing education in each college of nursing under the cooperation of Physical Education and Health Care Center in Nagaoka University of Technology.

### Reference


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