Comparison of HR–\(\dot{V}O_2\) Regression in Mental and Physical Exertion

Koichi Iwanaga\textsuperscript{1)}, Takashige Koba\textsuperscript{1)}, Kyosuke Masaki\textsuperscript{1)} and Sachio Ogita\textsuperscript{2)}

\textsuperscript{1)} Saga Research Institute, Osaka Pharmaceutical Co., Ltd., Higashifur, Kanzaki, Saga 842-01, Japan
\textsuperscript{2)} Osaka City Perinatal Center, I-Bainan, Nishinari, Osaka 557, Japan

Correlation between HR and \(\dot{V}O_2\) during video watching was studied in comparison with that during bicycle ergometer working. Five healthy males volunteered as subjects. Subjects watched video program for 60 minutes and worked on a bicycle ergometer with incremental work loads of 25 W/2 minutes for 13 minutes. \(\dot{V}O_2\) was significantly correlated with HR in both conditions, but the correlation coefficients and slopes of regression lines were lower in video watching than in bicycle ergometer working. Estimated energy expenditure during video watching from HR, based on the HR–\(\dot{V}O_2\) regression of bicycle ergometer working, was 111% of the measured value. It was suggested that estimation of daily energy expenditure using HR–\(\dot{V}O_2\) regression of dynamic work tend to be overestimated when daily life includes much mental work.

**Key words**: HR–\(\dot{V}O_2\) regression, Mental work, Dynamic work

Physical activity is considered an important factor in maintaining health and calls for exercise at home, in the work place, or in various sports facilities. Although both the oxygen intake (\(\dot{V}O_2\)) and heart rate (HR) are common basic indicators of the intensity of physical activity, HR is used more frequently because of its simple measurement in daily life and work. This indicator is used in determining the intensity of prescribed exercise and in estimating energy consumption based on the HR–\(\dot{V}O_2\) regression equation (Acheson et al, 1980; Harber et al, 1984). It is also well known that the HR of a person fluctuates due to mental exertion (Zwaga, 1973), body temperature (Iwanaga et al, 1983 and 1984), medication (Lawson, 1970; Sutton et al, 1977) and so on. Under current social circumstances where sedentary work is so prominent, a number of factors are responsible for HR fluctuations, with changes in physical activity representing only part of the variation in HR. To investigate the adequacy of HR as an indicator of the amount of physical activity in daily life, we examined HR changes while subjects watched a video program as a type of mental work, and determined the correlation between HR and \(\dot{V}O_2\) with that associated with physical exertion.

**METHODS**

The subjects were five healthy male adults who showed a mean age of 28 years (20–33 years), a mean height of 172.2 cm (169.7–176.3 cm), and a mean body weight of 61.1 kg (59.5–63.2 kg). They watched a 60-minutes video program in a climatic chamber shielded from outside noise and visual stimuli. During this sixty minutes, we performed continuous measurements of the HR by means of electrocardiogram chest leads and \(\dot{V}O_2\) from air exhaled into masks (Magna 88, Morgan). We devised a computer program for these parameters that produced values approximately every 10 seconds and calculated one-minute values, producing about six values per minute for each parameter. The measuring devices were installed outside the climatic chamber. The 60-minutes video program consisted of an adult movie, a landscape with background music, and a horror movie, in that order, each lasting 20 minutes.
In addition, the HR and $\dot{V}$O$_2$ were measured during work on a bicycle ergometer. After three minutes pedaling with no work (0 W), the work load was increased by 25 W every two minutes, to a maximum of 125 W in a 13-minutes period.

**Table 1.** Regression equations and correlation coefficients between HR (X, bpm) and $\dot{V}$O$_2$ (Y, ml/min) while video watching and ergometer working.

<table>
<thead>
<tr>
<th>Subj</th>
<th>Video Watching Regression Equation</th>
<th>r</th>
<th>$r^2$</th>
<th>n</th>
<th>Ergometer Working Regression Equation</th>
<th>r</th>
<th>$r^2$</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$Y = 2.0X + 111$</td>
<td>.268</td>
<td>.071</td>
<td>340</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>$Y = 7.2X - 323$</td>
<td>.545</td>
<td>.297</td>
<td>300</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>C</td>
<td>$Y = 2.1X + 108$</td>
<td>.248</td>
<td>.062</td>
<td>361</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>$Y = 2.8X + 45$</td>
<td>.282</td>
<td>.080</td>
<td>365</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>E</td>
<td>$Y = 2.8X + 130$</td>
<td>.328</td>
<td>.108</td>
<td>374</td>
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</tbody>
</table>

**RESULTS**

Despite instructions to the subjects to minimize body motion, HR variations differed among the three sections in the video program. The parameters showed little change during the portion showing...
landscape with background music. The five subjects showed a range of heart rate variation of 48, 35, 50, 61, and 62 bpm respectively during the 60 minutes of video watching.

Table 1 shows the correlation coefficient and regression equation between HR and $\dot{V}O_2$ for each subject during video watching and ergometer working. Significant positive correlations distributed over a fairly wide area were observed between the two parameters during video watching, with the r² in a range between 0.06 and 0.30.

Figure 1 shows the HR-$\dot{V}O_2$ regression lines for video watching and ergometer working for each subject. For all subjects, the slope of the regression line during TV watching was less than that during ergometer work.

**DISCUSSION**

The HR varies depending on the state of mental tension such as joy and anger in daily life, and experiments have shown that the HR fluctuates during mental work, such as doing simple calculations (Zwaga, 1973). The present study demonstrated that the HR fluctuated in response to the visual and auditory stimulation of video watching, and that the fluctuations corresponded with fluctuations in $\dot{V}O_2$. However, the HR changes during video watching do not constitute a satisfactory indicator of $\dot{V}O_2$ changes, and the slopes of the HR-$\dot{V}O_2$ regression lines during video watching were less than those during ergometer working. This suggests that HR variations during video watching are due to sympathetic excitation. This mechanism seems to be essentially different from increased activity of the cardio-pulmonary system due to increased oxygen demand in muscle tissue resulting from physical exertion. Therefore, as an indicator of the amount of physical activity in daily life, the HR is effective for physical work, but is questionable for a comprehensive evaluation of daily life which includes mental work.

Even during video watching, the HR increased to about 100 bpm. But with a similar HR level, $\dot{V}O_2$ during video watching was fairly smaller than during ergometer working. Therefore, estimates of energy expenditure from HR based on HR-$\dot{V}O_2$ regression equation of physical exertion, are likely to produce inflated values as the proportion of mental work in daily life increases. Calculation of the energy expenditure during video watching on the basis of the HR-$\dot{V}O_2$ regression equation of ergometer working resulted in an overestimation of 111% against the observed mean values for five subjects. Thus, an inflated value for mental work should be taken into account in calculating energy expenditure from HR using HR-$\dot{V}O_2$ regression equation of dynamic work.

**REFERENCE**


