

Validity of heart-rate based measurements of oxygen consumption during work with light and moderate physical activity

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Abstract. For ergonomic purposes it is useful to quantify the energy expenditure and the level of physical activity imposed on workers. Oxygen consumption (VO_2) is often used to calculate energy expenditure and can be used as an indication of physical activity. Twenty-five subjects participated in the study. Oxygen consumption (VO_2) in L O_2 /min and heart-rate (HR) in beats per minute (bpm) were simultaneously measured during different work tasks at each individual's workplace. Ninety-one different work tasks with light or moderate physical activity were included (physical activity was classified by the VO_2 measurements). Estimated oxygen consumption (L O_2 /min) was then calculated by using the HR measurements in bpm combined with individual HR- VO_2 equations established in a laboratory. Although heart-rate based estimations of individual oxygen consumption showed relatively low precision, heart-rate measurements in combination with individual exponential HR- VO_2 equations can be used to discriminate between work involving light physical activity and work involving moderate physical activity.

Keywords: energy expenditure, work load, exposure assessment, heart rate, oxygen consumption

1. Introduction

For ergonomic purposes it is useful to quantify the energy expenditure and the level of physical activity imposed on workers. Oxygen consumption (VO_2) is often used to calculate energy expenditure and can be used as an indication of physical activity. Work involving heavy physical activity is often combined with use of high muscle forces. This can lead to musculoskeletal disorders [2-4, 6]. In physically strenuous work with heavy physical activity, periods of recovery are important to prevent the total physical load during a working day from exceeding an individual's threshold levels [1, 5, 7].

The present study addressed two research questions: 1) Can heart-rate based measurements be used to discriminate between work involving light physical activity and work involving moderate physical activity? And 2) what is the precision of heart-rate based estimations of oxygen consumption in work with light or moderate physical activity?

2. Methods

Twenty-five subjects participated in the study. Oxygen consumption (VO_2) in L O_2 /min and heart-rate (HR) in beats per minute (bpm) were simultaneously measured during different work tasks at each individual's workplace. Ninety-one different work tasks with light or moderate physical activity were included (physical activity was classified by the VO_2 measurements). Estimated oxygen consumption (VO_{2EST}) (L O_2 /min) was then calculated by using the HR measurements in bpm combined with individual HR- VO_2 equations established in a laboratory.

3. Results

Direct HR measurements in bpm to estimate the level of physical activity correctly classified 60 of the 91 work tasks. The alternative VO_{2EST} -method correctly classified estimated level of physical activity

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for 82 of 91 work tasks. The mean difference between VO_2 and VO_{2EST} for work tasks with light or moderate physical activity was 0.05 (95%CI; 0.02-

0.08) L O_2 /min and the \pm 95% limits of agreement was \pm 0.27 L O_2 /min (figure 1).

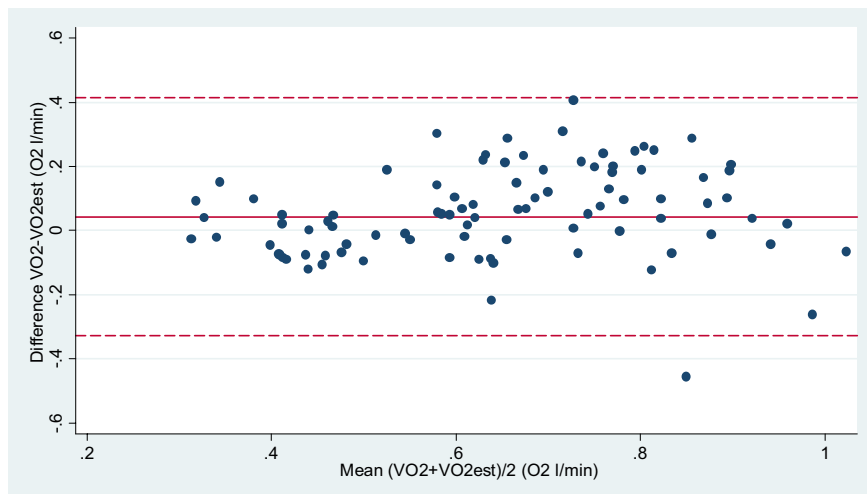


Figure. 1. Work tasks with light or moderate physical activity. Bland-Altman plot of the differences between measured oxygen consumption (VO_2) and the estimated oxygen consumption from the heart-rate measurements (VO_{2EST}) (L O_2 /min). The solid line represents the mean difference. Dashed lines represent upper and lower limits of agreement, calculated as the mean differences \pm 1.96 SD (L O_2 /min). Number of work tasks (n=91).

4. Discussion

Although heart-rate based estimations of individual oxygen consumption showed relatively low precision, heart-rate measurements in combination with individual exponential HR- VO_2 equations can be used to discriminate between work involving light physical activity and work involving moderate physical activity.

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