A NOVEL METHOD FOR USING HEART RATE VARIABILITY DATA FOR ESTIMATION OF OXYGEN CONSUMPTION AND ENERGY EXPENDITURE: A VALIDATION STUDY

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Heart rate (HR) is commonly used to estimate oxygen consumption (VO2), and energy expenditure (EE) in the field. Most of the available estimation methods require a separate calibration test in the laboratory, and assume a steady-state relationship between HR and VO2. In daily life, however, the HR/ VO2 relationship may be affected by non-metabolic factors during low intensity activities, and by dynamically changing intensity levels. The aim of the study was to examine the validity of a new neural network-, and HR- and HR variability-based method (Firstbeat PRO heartbeat analysis software) in estimating VO2, and EE. The method takes into account the on/off dynamics in HR/ VO2 relationship, and HR variability based breathing frequency. The individual resting and maximal HRs, and the VO2max are estimated from a person's background variables, and no separate calibration tests are needed. Ten men and 10 women performed 25 different tasks representing different types of daily activities. During the tasks, portable devices were used to record and measure electrocardiograms (Alive Heart Monitor, Alive Technologies Pty. Ltd.), and VO2 including respiratory parameters (Oxycon Mobile Jaeger, Viasys Healthcare Inc.). From the beat-by-beat and breath-by-breath data averages were calculated for each task for further analysis. The within subject correlations between the measured and estimated VO2-values for the 25 tasks were high (range 0.88-0.97) with R2 being 0.87. The estimation method under-predicted slightly the measured VO2 (mean difference – 1.5 ml/min/kg, CI -8.4, 5.4 ml/min/kg). During sedentary/low intensity tasks, the measured and predicted VO2 values did not differ (mean $\pm$ SD, 4.1 $\pm$ 0.4 vs. 4.2 $\pm$ 1.1 ml/min/kg). Corresponding values for moderate and heavy intensity tasks were 13.5 $\pm$ 1.1 vs. 10.0 $\pm$ 2.3 ($p < 0.01$), and 24.0 $\pm$ 1.1 vs. 22.2 $\pm$ 2.3 ml/min/kg ($p<0.01$), respectively. The total EE over the 25 tasks was 315 $\pm$ 46 kcal by indirect calorimetry, and 288 $\pm$ 57 kcal ($p < 0.01$) by the estimation method. The within subject correlations between the measured and estimated breathing frequencies were moderately high (range 0.67-0.96, R 2 = 0.62). Climbing stairs up and down and recovery from treadmill running were chosen to represent rapidly changing exercise intensities, and analyzed in a more detail in the validation. The within subject correlations between the measured and estimated VO2-values averaged 0.80 $\pm$ 0.18 in the climbing task, and 0.83 $\pm$ 0.22 during the recovery from running, respectively. In conclusion, the new method provides adequate estimates of breathing frequency and on/off-kinetics of HR and VO2, and consequently the VO2 and EE, especially during sedentary/light and heavy activities and when dynamic changes occur in physical activity. The new HR- and HR variability- based method allows the quantification of spontaneous and complex daily activity patterns without separate individual calibration in the laboratory.

Keywords: Oxygen Consumption, Energy Expenditure, Heart Rate Variability