Energy expenditure can be accurately estimated from HR without individual laboratory calibration

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Current heart rate (HR) based energy expenditure (EE) estimation methods are inaccurate. Flex-HR method is currently most accurate, but it requires individual calibration in laboratory limiting applicability for large-scale daily use under free-living conditions. A recent method utilizing RR-interval (RR) derived data on heart rate, respiratory frequency and On-Off dynamics has increased the accuracy of HR-based VO₂-estimation (RRVO₂, Pulkkinen et al., MSSE 36(5), 2004).

PURPOSE: To evaluate whether EE during daily life tasks and physical exercises can be estimated accurately using RRVO₂ without individual laboratory calibration.

METHODS: HR and breath-by-breath VO₂ data from 16 male and 16 female healthy untrained adults (age of 38±11 yr, mean weight 68.1±11 kg, VO₂ MAX 44.9±9.5 mL/min/kg) were collected 5 minutes prior to, during and 15 minutes after 10-min exercises at 40% and 70% VO₂ MAX and maximal stepwise test (MAX) on bicycle ergometer. Two 50 min series of simulated low intensity real life tasks (RLT1 & RLT2, mean HR 101±8 and 105±9 bpm) were also carried out. Steady-state from RLTs were used to construct individual (FLEXIND) and mean for all subjects (FLEXALL) equation slopes and intercepts to calculate EE. Flex HR under which EE can be estimated at resting level was determined as the mean of the highest 1 min HR during baseline and lowest HR during MAX. RRI data was used to calculate EE with RRVO₂ model (Pulkkinen et al., 2004). Accuracy was evaluated using mean absolute error (MAE) and r between the estimated and the measured. RESULTS: Age, gender, weight, height and BMI were included in Cox regression and estimated HR was estimated from RRI using specialized neural network equations. The results indicate that by using conventional laboratory calibrated flex-HR most EE can be estimated with reasonable accuracy during daily exercise. The results suggest, that by using conventional laboratory calibrated flex-HR method and two methods not requiring individual calibration

INTRODUCTION

Heart rate (HR) recording is a very common method to estimate energy expenditure. The relationship between HR and EE is near-linear at moderate intensity exercise. HR to EE equation is affected by several confounding factors, e.g., non-physical activity related HR reactivity at low intensity, dynamic changes in exercise intensity, type of the exercise and environmental conditions. HR to EE relationship is also highly individual requiring currently laboratory calibration. Flex-HR method has been developed assuming EE to be at resting level below so called flex-HR reducing error at low HRs. A recent neural network method utilizing RR-interval (RR) derived data on HR, respiratory frequency and On-Off dynamics has increased the accuracy of HR-based VO₂-estimation (RRVO₂, Pulkkinen et al., MSSE 36(5), 2004). The purpose was to evaluate whether EE can be accurately estimated using method utilizing RR-interval data compared with individually calibrated flex-HR method and two methods not requiring individual calibration.

METHODS

Descriptive data on the subjects is presented in table 1. Subjects completed bicycle ergometer (Ergoline, Bitz, Germany) exercises and real life tasks (RLT) described in figure 1. Resting HR and EE values were recorded during 15-minute baseline (BL) period at different postures. RLT included usual everyday house- hold, recreational and occupational tasks, such as: sweeping the floor, walking, walking in stairs, carrying load, pushing shopping carts, lifting and moving light weights, computer tasks and free standing and sitting. Beat-by-beat HR-data was collected with record or (Polar Electro Oy, Kepple, Finland). VO₂ data was collected breath-by-breath using Vmax Sensor Medic, California, Palo Alto, USA) during bicycle ergometer exercises and portable Cosmed K4 analyser (Torino, Italy) during RLT's. Energy expenditure was calculated from VO₂ using non-protein caloric equivalents for oxygen.

RESULTS

Flex-HR was on average 93±10 bpm. Mean EE across all five tasks for subjects was 740±342 kcal. Measured EE and mean HR for each task is presented in table 3. Across subjects, MAE was smallest with RRVO₂ and highest with RREEST and HIILEST (figure 2). Estimated EE differed significantly form measured EE during RLT's (table 3). RRVO₂ was the only method that did not differ from measured during all tasks.

SUMMARY: MAE of different tasks (table 3) and r between measured and estimated EE for RRVO₂, FLEXIND, FLEXALL, RREEST, HIILEST and HIILEST were 139, 185, 191, 270 and 246 kcal, and 0.81, 0.77, 0.71 and 0.78, respectively. Table 3. Mean HR as well as measured and MAE (both in kcal and mean of 200) across different tasks including baseline, exercise and recovery phases.

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REFERENCES
