

Estimation of energy expenditure using tri-axial accelerometry and cardiac recordings

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Accurate continuous measurement of physical activity in a natural setting can provide critical information on the role of physical activity in the etiology of obesity and diabetes and can also be used to detect mood-related reductions in daily activities in psychiatric disorders such as depression. Physical activity can be defined as any bodily movement produced by skeletal muscles that results in energy expenditure (EE).

The purpose of this study was to test the validity of a new approach to quantify energy expenditure in an ambulatory setting by combining the information from a tri-axial accelerometer worn on the hip and wrist-watch actigraphy with the recording of heart rate (HR) and heart rate variability (HRV).

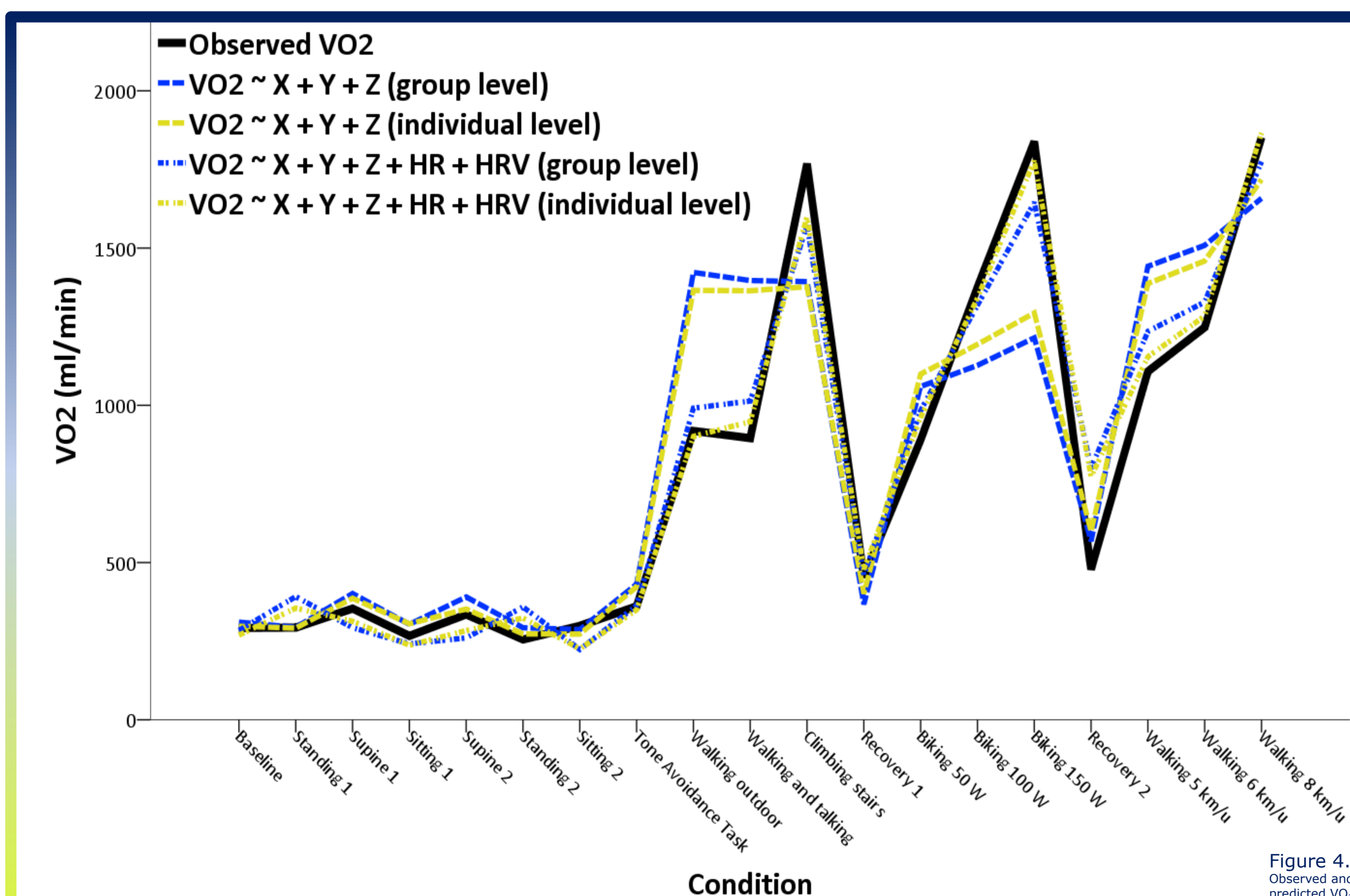
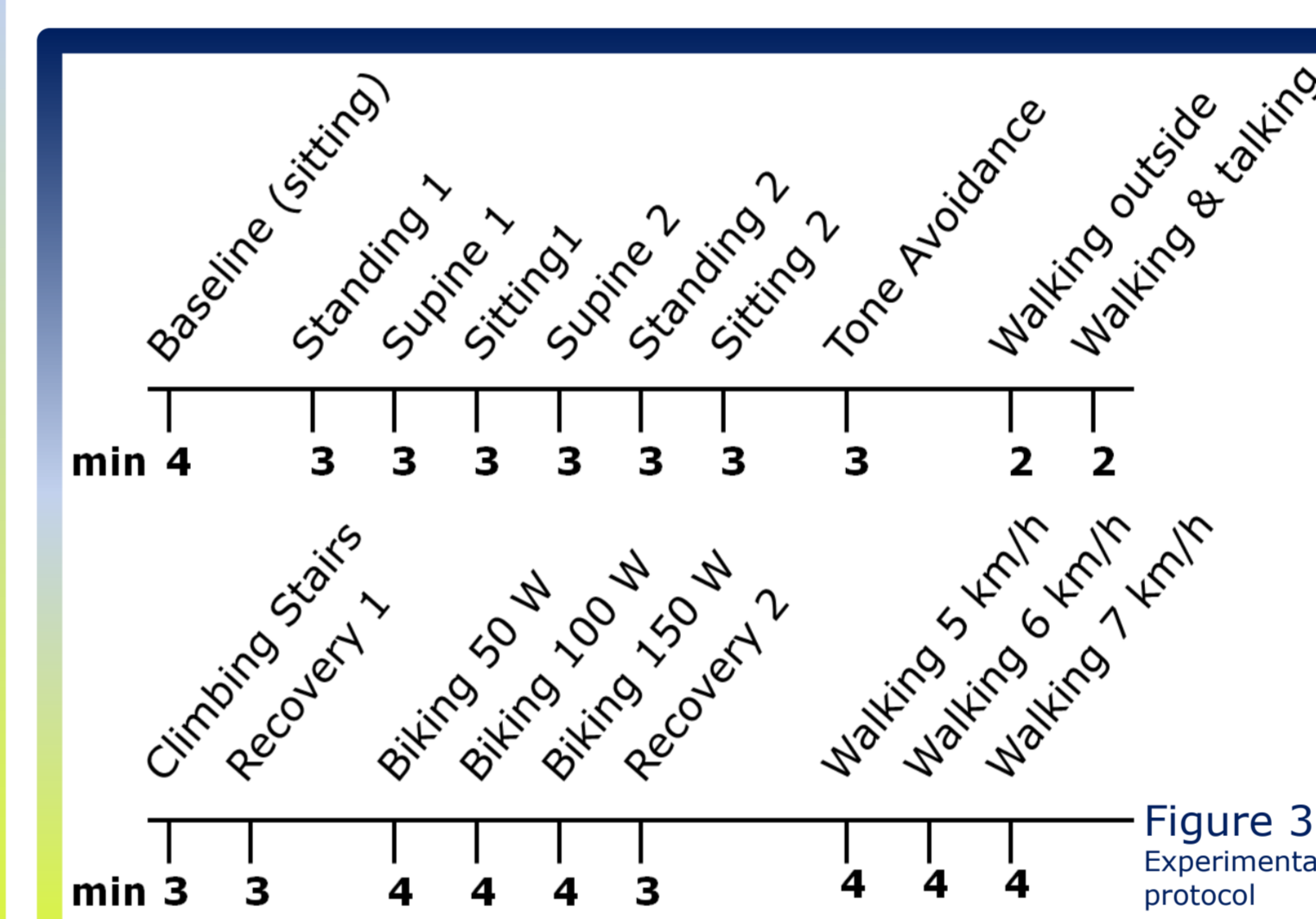
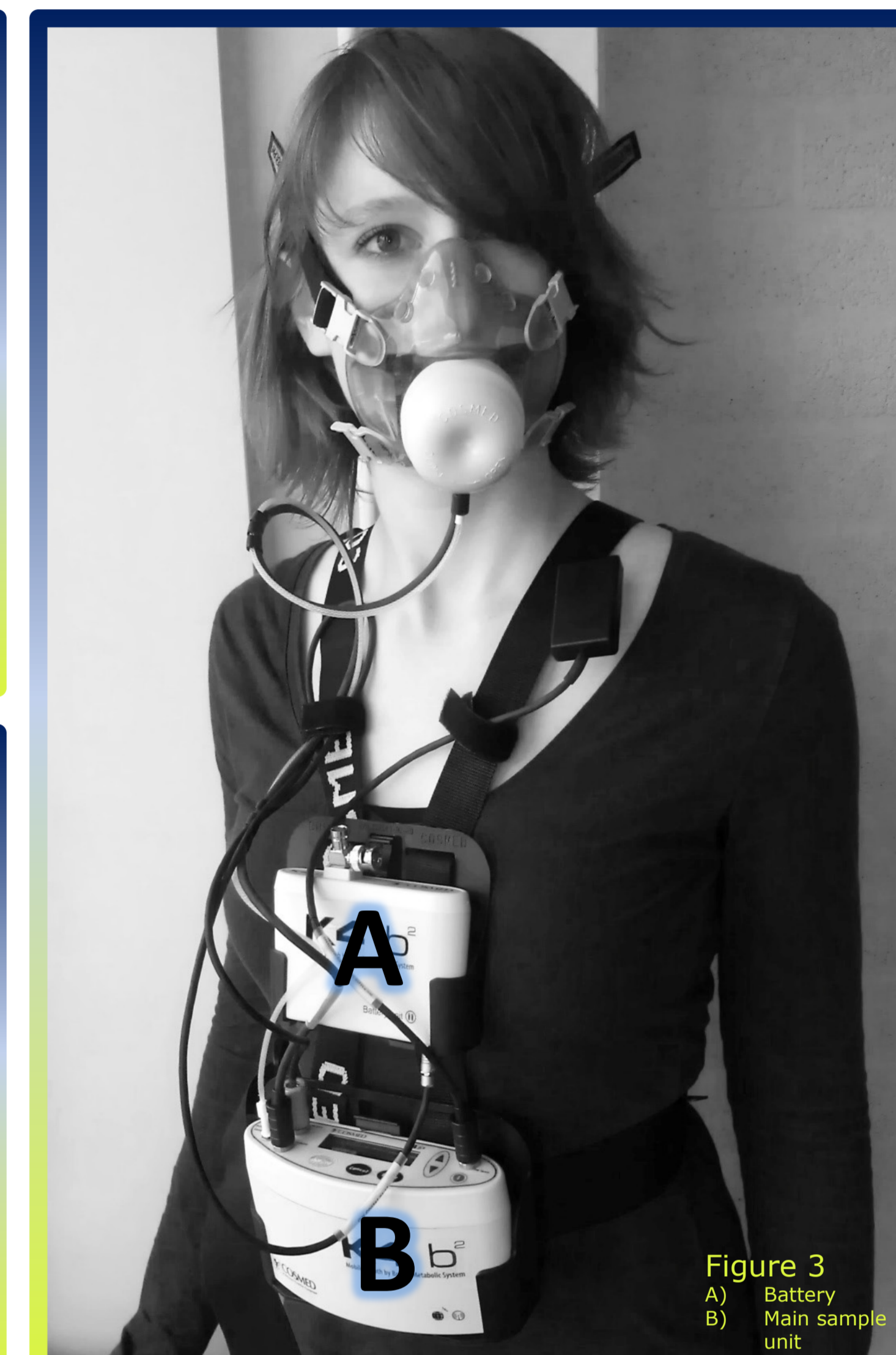
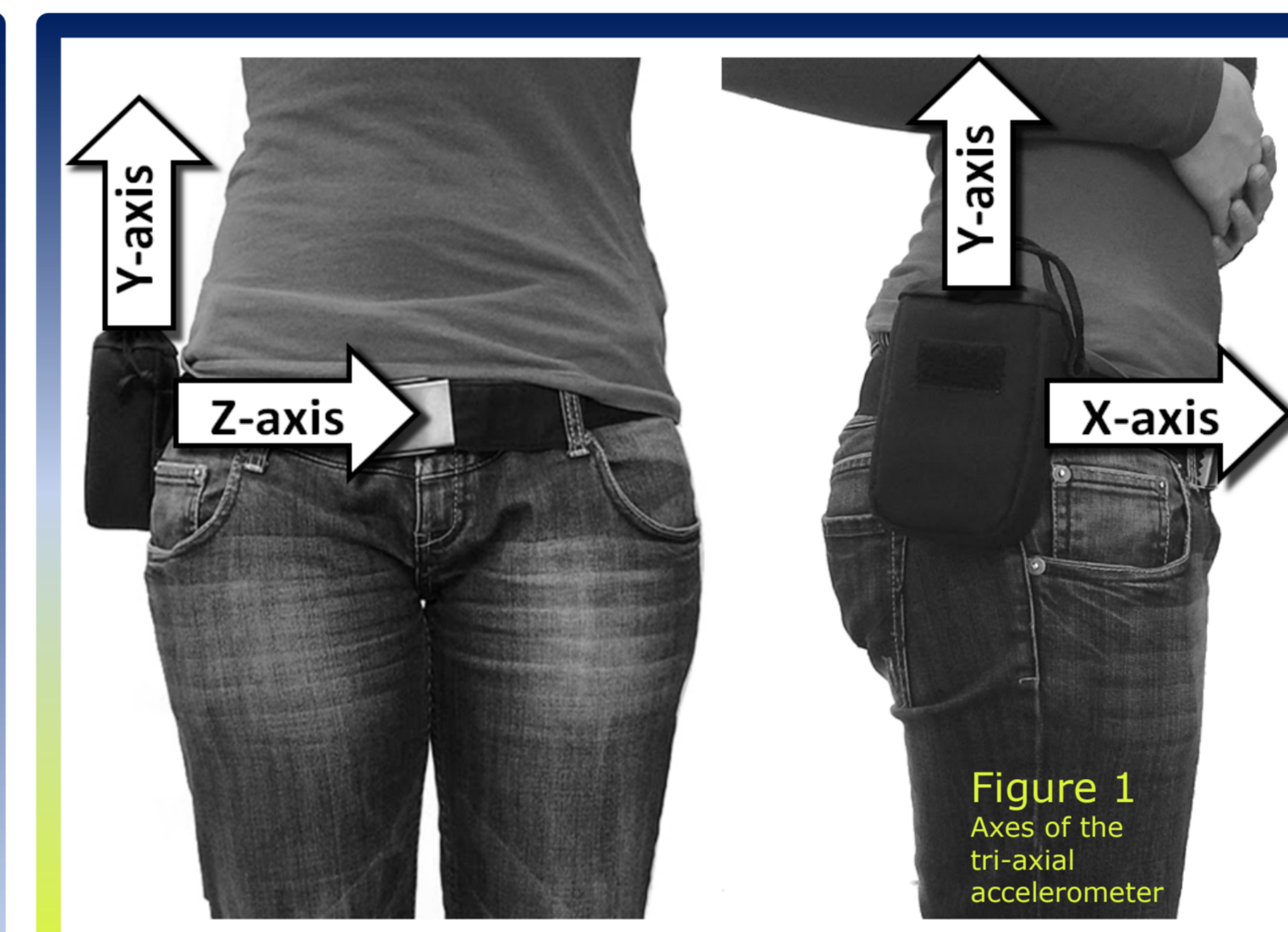
METHODS

27 subjects were equipped with an ambulatory ECG recorder (Figure 1) with inbuilt tri-axial accelerometer and a wrist watch actigraph. Simultaneously, EE was measured by continuous recording of the oxygen consumption (VO_2) (Figure 2), the gold standard for EE, while they performed various activities (Figure 3).

The relationship between VO_2 and two sets of predictors was explored:

- 1) X-axis, Y-axis, Z-axis and Actiwatch counts;
- 2) X-axis, Y-axis, Z-axis and Actiwatch counts extended with HR and HRV to examine whether these cardiac signals improve the estimation of VO_2 .

Furthermore, multilevel analyses tested whether allowing for individual differences in the slopes of the predictor- VO_2 relationship improved on predictions that used a fixed set of slopes for all subjects.



RESULTS

Using tri-axial accelerometry only, fixed regression coefficients for all subjects (group level) explained **73.8%** of the variance in VO_2 . Adding accelerometer data from a different body location (wrist-watch actigraphy) did not improve the prediction of EE.

The addition of HR and HRV increased the prediction of EE: this model explained **88.3%** of the variance in VO_2 . When allowing for individual differences in the slope of the predictor- VO_2 relationships (individual level), the model explained **93.9%** of the variance in observed VO_2 . To achieve this 6% improvement in accuracy it would be required to add a laboratory calibration step for each subject before actual ambulatory recording.

Figure 4 plots the observed VO_2 against the predicted VO_2 under these models.

CONCLUSION

We conclude that energy expenditure can be predicted with a very high reliability from a hip-worn tri-axial accelerometer, HR and HRV. These signals can be recorded with a minimal burden to the subjects in real life settings, and should become a new standard in the epidemiology of physical activity.

