ABSTRACT
At present, there are useful methods for monitoring fatigue accumulation during exercise. Heart rate during exercise gives information on the intensity of exercise but it does not take into account the cumulative effect of exercise duration. Information on body fatigue can be obtained using invasive procedures (e.g., blood sampling and analysis) or measurements (e.g., heart rate) during recovery after exercise. After exercise, oxygen consumption (VO2) does not return to resting level immediately but rather in a curvilinear fashion. The causes of Excess Post-exercise Oxygen Consumption (EPOC) after exercise may not be totally clear but based on literature it is hypothesized that the greater the fatigue accumulation during exercise the greater the EPOC and the longer the time required for VO2 to recover to pre-exercise level.

PURPOSE
The purpose of this study was to develop a method for pre-predicting the amount of EPOC from the information recorded before and during exercise and to compare the pre-predicted EPOC with the actual measured EPOC after exercise.

METHODS
Pre-prediction
Based on meta-analysis of 48 peer-reviewed articles including 158 subjects in different exercise settings (duration and intensity ranging from 2 to 90 minutes and from 18% to 108% of VO2max, respectively) a computational model based on heart function (patent pending) for pre-predicting EPOC (EPOCpred) was constructed. A total of 32 healthy adult subjects (16 males, 16 females) with age 18-19 years (mean SD weight 69.6 ± 10.9, height 171.6 ± 6.5 and VO2max 44.0 ± 10.8 ml/kg/min) served as a separate validation set. Subjects carried out two 10-minute constant load exercises at intensities of 40% and 70% VO2max and a maximal stepwise test to voluntary exhaustion.

RESULTS
EPOCpred was pre-predicted from ECG RR-interval data collected with Polar RR-recorder. After exercise, VO2 was measured using Vmax analyzer (Sensor Medics), respectively.

DISCUSSION
The results indicate that the EPOC could be pre-predicted from the RR-interval data recorded during the exercises. The results also indicated that at low intensity exercises (<40%VO2max) there was a significant correlation between EPOCpred and EPOCmeas, as well as EPOCpred and the corresponding blood lactate concentration. At maximal exercise the correlation between EPOCpred and blood lactate concentration was poor confirming that other factors, such as body temperature and hormonal changes may influence the EPOC, fatigue accumulation and prolongation of recovery during high intensity exercise.

CONCLUSIONS
(1) EPOC can be pre-predicted from data recorded during exercise.
(2) Only RR-interval measurement is needed for the pre-prediction.
(3) If blood lactate concentration and actual EPOC can be measured it may serve as a tool for monitoring fatigue accumulation during exercise.
(4) Requiring only RR-interval monitoring for maximal exercise were a total of 32 healthy adult subjects (8 fit and 8 less fit males and females) served as a separate validation set.

Table 1. Mean ± SD data for the submaximal and maximal exercises.

Table 2. Mean ± SD data for the submaximal and maximal exercises.

Table 3. Correlations between EPOCpred and EPOCmeas and Mean Absolute Error (MAE) for the pooled data of all exercises, for the pooled data of 40% and 70% submaximal exercises and for the maximal exercise.

Table 4. Correlations between EPOCpred and VO2max and blood lactate concentration.

Figure 1. Submaximal and maximal exercise protocols on cycle ergometer.

Figure 2. Heart rate, VO2 and EPOCpred accumulation during exercises.

Figure 3. Correlation between pre-predicted and measured EPOC.

Figure 4. Correlation between pre-predicted EPOC and blood lactate concentration.

Figure 5. Heart rate and EPOCmax accumulation during a training session.