

Photo-Plethysmography Heart Rate and Activity Measures during Exercise

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Heart rate (HR) monitors enable users to accurately gauge their HR during exercise. Many HR monitors use a chest strap to detect the heart's electrical signal (ES); yet new wrist-worn devices rely on optical blood flow sensing technology known as photo-plethysmography (PPG) to measure HR and use an accelerometer to track exercise that are synced to a personal website. The accuracy of PPG for measuring HR during exercise is unclear and the extent that PPG devices accurately quantify exercise time is unknown. **Purpose:** To examine the measurement congruence between PPG and ES HR monitors during 30 minutes of treadmill exercise. A second purpose was to compare minutes of exercise between PPG website and observed exercise time. **Methods:** Subjects were 21 male (n=9) and female (n=12) adults between 18-35 years of age who concurrently wore both monitors during seated rest, warm-up, treadmill exercise, and cool-down (5, 5, 30, 5-10 minutes, respectively). HR was recorded each minute and PPG website accounts were accessed to obtain minutes of recorded exercise. Pearson correlations examined HR associations between PPG and ES. Paired t-test was used to assess differences in HR between PPG and ES. Mean absolute percent error (MAPE) was calculated for PPG. Bland-Altman plots and a 95% equivalence test was used to explain overall agreement between PPG and ES. Differences between PPG website and observed exercise minutes were examined with Paired t-test. **Results:** Mean exercise HR was strongly correlated between PPG and ES ($r=.961$, $p<.05$). PPG significantly underestimated mean exercise HR compared to ES (154.61 ± 14.36 ; 158.15 ± 14.12 bpm, $p<.05$). MAPE was 2.23% for PPG and the 95% equivalence test showed PPG HRs fell within a $\pm 5\%$ equivalence zone of the mean ES HR ($150.24 - 166.06$ bpm). Compared to observed exercise time, PPG website recorded significantly greater exercise time (34.93 ± 3.61 ; 29.52 ± 2.18 min, $p<.05$). **Conclusion:** PPG significantly underestimated ES HRs during exercise, yet equivalency tests revealed PPG HRs were comparable to ES. The low MAPE value and use of a more restrictive equivalency zone support the utility of PPG for measuring HR during exercise. The finding that PPG overestimated minutes of exercise may be due to HR response during warm-up, exercise, and cool-down, though additional research is warranted.