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 synched 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 ± 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.