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Jonathan D. Kenyon
Virginia Commonwealth University

Hayley Billingsley
Virginia Commonwealth University

Natalie J. Bohmke
Virginia Commonwealth University

See next page for additional authors

Authors

Jonathan D. Kenyon, Hayley Billingsley, Natalie J. Bohmke, Danielle Kirkman, Salvatore Carbone, and Youngdeok Kim

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Jonathan Kenyon, MS; Hayley Billingsley, RD, MS, CEP; Natalie Bohmke, MS, EP-C; Danielle Kirkman, PhD; Salvatore Carbone, PhD; Youngdeok Kim, PhD

Virginia Commonwealth University, Department of Kinesiology and Health Sciences, Richmond, VA

Introduction

Low physical activity is associated with heart failure with preserved ejection fraction (HFpEF), which has a poor prognosis and high risk of mortality. Step-counts, a measure of physical activity, can be estimated via accelerometry. To date, few studies have examined validity of accelerometer-derived step-counts in the adults with HFpEF. The purpose of this study was to assess criterion validity of the Actigraph GT9X accelerometer step-count function in adults with HFpEF via ankle, waist, and wrist placement, compared with manually-counted observed steps.

Methodology

Subjects

- Obese adults ≥18y with a confirmed clinical diagnosis of stable heart failure and left ventricular ejection fraction >50% documented in the prior 12 months

Devices

- Actigraph GT9X tri-axial accelerometer worn on the ankle, waist, and wrist
- Sample rate of 60 Hz
- Data downloaded into 1-second and 10-second epochs

Criterion Measure

- Manually counted timestamped steps (OS) as criterion measure

Figure 1: Actigraph GT9X Accelerometer with Wrist Strap

Laboratory Validation

- Incremental cardiopulmonary exercise test (CPET) on a treadmill (optional handrail support) with open-circuit spirometry
  - Spirometry data sampled in 10-second epochs

Statistical Analysis

- Paired *t* tests to determine whether mean total steps (TS) from the three devices were significantly different from the mean TS from OS
- Pearson correlations to determine associations between device-measured TS and the total OS
- Simple linear regression models used to assess the effect of walking speed on absolute percentage error (APE) of the devices compared to OS
- Agreement of the devices throughout the duration of the CPET examined using Pearson correlations
- Alpha set at 0.05 for all statistical analyses

Results

The descriptive statistics of subjects at baseline are presented in Table 1. Mean TS from OS and the three accelerometers are presented in Table 2. TS from waist-worn (t = -5.29, p = .001) and wrist-worn (t = -12.50, p < .001) devices were significantly lower than TS from OS (Table 3). Only TS from the ankle GT9X was significantly associated with TS from OS (r = 0.974, p = .001). GT9X-estimated steps from the ankle (r = 0.869, p < .001), waist (r = 0.550, p < .001), and wrist (r = 0.429, p <.001) were all significantly associated with OS-measured steps. Absolute percentage error was significantly and negatively associated with treadmill speed for devices on the ankle (b = -10.70, p < .001), waist (b = -32.49, p < .001) and wrist (b = -10.08, p < .001). Additional results of the regression models can be seen in Figure 2.

Table 1: Subject Characteristics (n=6, 100% female)

Age (years)	Height (cm)	Weight (kg)	BMI (kg/m^2)
57.2 ± 9.43	166.4 ± 5.93	120.2 ± 32.0	43.0 ± 8.92

Mean ± Standard Deviation. Body Mass Index (BMI), centimeters (cm), kilograms (kg), kilograms per meter squared (kg/m^2).

Table 2: Total Steps During Cardiopulmonary Exercise Testing

OS (count)	Ankle (count)	Waist (count)	Wrist (count)
776.0 ± 144.1	792.3 ± 155.3	460.0 ± 188.6	166.0 ± 148.4

Mean ± Standard Deviation of total steps during cardiopulmonary exercise testing. Manually counted steps (OS).

Table 3: Correlations, *t* statistics, and MAPE between GT9X-derived and OS-derived TS

Device	Pearson's *r*	*t* statistic	MAPE (%)
Ankle	0.974 (.001)*	-1.95 (.109)	4.22
Waist	0.511 (.195)	-5.29 (.001)*	41.34
Wrist	0.554 (.154)	-12.50 (<.0001)*	79.94

Pearson's correlations, *t* statistics, and Mean Absolute Percentage Error (MAPE) between device-measured total steps (TS) and manually counted TS (OS). Correlations and *t* statistics are presented with *p*-values. * indicates $p \leq .05$.

Discussion

Discussion

- The main findings of this study were that 1) ankle-placed GT9X devices are more strongly associated with manually counted steps than waist- and wrist-worn devices during treadmill walking, 2) the GT9X accelerometer estimates steps with less error at higher treadmill walking speeds regardless of anatomical placement
- This is one of the first studies to validate a tri-axial accelerometer step-count function in the HFpEF population in a laboratory setting
- Limitations:
  - Optional use of handrail support during CPET likely caused wrist-worn devices to greatly underestimate steps
  - No statistical adjustment for obesity may have limited the ability to draw conclusions about the accuracy of the devices
  - Small sample size

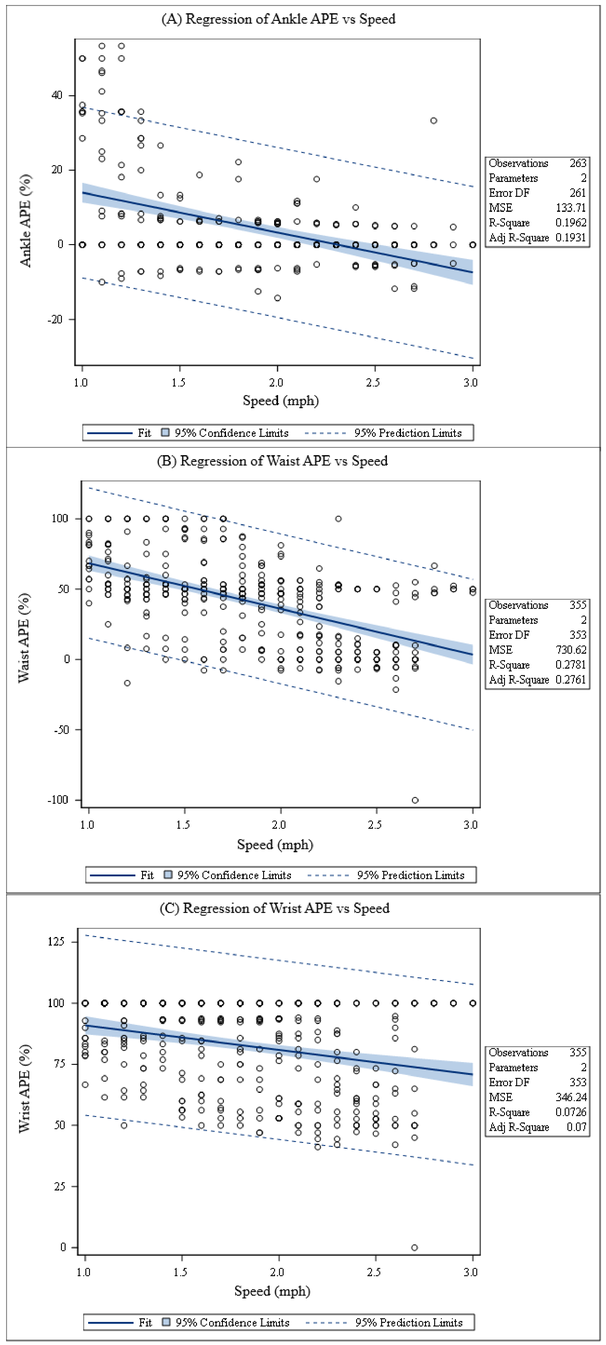

Figure 2: Regression Models of device Absolute Percentage Error (APE) vs walking speed in miles per hour (mph). Plot (A) includes the model for the Ankle. Plot (B) includes the model for the waist. Plot (C) includes the model for the wrist.

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