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Validation of Activity Trackers in a Laboratory Setting with Young Adults

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ABSTRACT

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Setting with Young Adults

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Background: Objectively tracking sedentary behavior (SB) and physical activity (PA) is becoming increasingly important as research continues to show the negative effects with increasing SB and decreasing PA.

Objectives: The purpose of this study was to evaluate three commercial activity trackers with young adults regarding how they accurately measure SB and PA behaviors in a laboratory setting.

Methods: 50 college-aged participants wore three wrist-based activity trackers (Fitbit Surge, Apple Watch, and Basis Peak) and two ActiGraph accelerometer devices during a series of SB and PA behaviors for five-minute intervals in a laboratory setting. The activity trackers were evaluated against direct observation and the ActiGraph devices, placed on the hip and wrist, which are consistent with the National Health and Nutrition Examination Survey (NHANES) standards of measure.

Results: Overall accuracy during the SBs compared to direct observation was high, with Apple (99.0%), Basis (99.0%), and Fitbit (94.9%) performing similar to the Hip ActiGraph (95.1%) and markedly better than the Wrist ActiGraph (58.6%). Overall significant correlations ($p \leq 0.05$) during the PAs were higher with the Wrist ActiGraph (66.7%) than with the Hip ActiGraph (8.3%). The Wrist and Hip ActiGraphs significantly correlated in three out of four SBs, but not in any PA behaviors.

Discussion: Activity trackers are reliable when determining sedentary behavior, tend to overestimate step count during light walking, and underestimate activity level when biking. Also, the Wrist ActiGraph consistently underestimated both SB and PA step count compared to the Hip ActiGraph. While some variability is seen in the validity of the activity trackers, each activity tracker studied has its strengths and weaknesses. Understanding these strengths and limitations helps healthcare professionals more accurately interpret recorded data based on the patient specific device.

Keywords: fitness trackers, sedentary lifestyle, physical activity, accelerometer

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Setting with Young Adults

Decreases in PA and increasing SB are growing concerns both nationally and internationally. Declines in PA are well documented (Center for Disease Control and Prevention [CDC], 2014). Meanwhile, the related rise in SB has also been associated with adverse health effects (Diaz et al., 2017; González, Fuentes, & Márquez, 2017). In fact, the rise in SB has led some researchers and media outlets to coin the phrase, “sitting is the new smoking” (Yoder-Wise, 2014, p. 523).

In recognition of these growing health concerns, numerous organizations have outlined ways to promote PA and discourage SB (Tremblay et al., 2016; World Health Organization [WHO], 2010). These guidelines serve as excellent resources for primary care providers (PCPs) in educating patients.

Educating patients is a critical aspect of patient-centered care (Shaller, 2007). The Institute of Medicine has identified patient-centered care as one of six domains of quality healthcare (Press, 2001). In an effort to improve health care quality, health care providers can use PA and SB recommendations and an understanding of patients’ current activity levels as a guide to educate patients on an individual basis and create personalized, patient-centered care plans addressing PA and SB levels.

Health care providers, such as PCPs and nurses, recognize health promotion and education as important aspects of quality healthcare. However, implementation at an effective level is difficult for several reasons. One reason is time constraints during patient appointments make it difficult to cover health promotion topics (Konrad, 2010). Additionally, PCPs may not comprehend the full nature of the patients’ needs, as recall ability affects how patients report their own SB and PA (Strath et al., 2013). Similarly, self-reporting bias can cause an underestimation of SB and an overestimation of PA (Bond et al., 2013).

Activity trackers could help address the problems of both time constraints and understanding a patient's individual needs. Activity trackers provide objective feedback to consumers about their activity levels (Kooiman et al., 2015). In like manner, activity trackers can provide objective feedback to PCPs about the PA of their patients wearing trackers. In order to rely on the data, however, PCPs need to ensure that the data are valid and accurate.

As the gold standard of measurement, the National Health and Nutrition Examination Survey (NHANES) uses research-grade accelerometer devices made by ActiGraph to assess PA and SB. Unfortunately, ActiGraph devices are impractical to use in a typical healthcare setting; they provide no user feedback from the device and have a high price point, as they are designed specifically for research and data collection. The purpose of this study was to evaluate three commercial activity trackers and how they objectively measure SB and PA behaviors in a laboratory setting. The activity trackers Apple Watch, Basis Peak, and Fitbit Surge were evaluated against the research-grade Hip and Wrist ActiGraph, consistent with the NHANES standards of measure.

Methods

Participants

Research activities were approved by a university institutional review board. Subjects included a convenience sample of young adult (aged 18 to 29 years) college students and community members of various socio-demographic backgrounds. Participants were recruited by word of mouth, posted flyers, social media, and email.

When recruits contacted researchers, eligibility was determined based on a passing a pre-screening to determine if the inclusion/exclusion criteria were met. Potential participants completed the Physical Activity Readiness Questionnaire (see Appendix A) as an initial screening for eligibility, requiring all “no” answers to participate. Inclusion criteria were: males and females aged 18 to 29 years old, who were able to (1) wear hip and wrist accelerometers and activity trackers; and (2) perform the following activities: lying down, sitting, typing on the computer, standing, using a stationary bike (at moderate and vigorous speeds), and walking on a treadmill (at light and moderate speeds). Recruits were excluded if they were unable to perform all of the activities in one session or had any type of body injury or condition such that performing the activities was difficult, worsened the condition, or sufficiently altered the participant’s normal routine or physical ability. For example, a recruit who was otherwise healthy but was dependent on crutches, or who was pregnant, was not eligible to participate.

Sample and Setting

A sample size of 50 participants was selected based on the sample size of similar studies of n=50 (Sasaki, John, & Freedson, 2011), n=36 (Carr & Mahar, 2011), and n=28 (Peterson, Sirard, Kulbok, DeBoer, & Erickson, 2015). Because the two smaller studies were underpowered, the recruitment goal for this study was 50 subjects, which would accommodate for some attrition. The research study was performed at the Human Performance Lab on a large private university in the western United States.

Procedures

This study was performed over a 12-month span. Basic demographic and body size (height and weight) were measured in duplicate and averaged. Subjects reviewed and completed consent forms and were fitted with research-grade ActiGraph accelerometer devices over the right hip (on an elastic band around the waist) and wrist (via velcro strap), and three activity trackers on the wrists. Wrist placement of the accelerometer and activity trackers (two per wrist) was randomly rotated from subject to subject in order to reduce placement as a confounding variable on the results. Subjects then participated in a total of eight activities in the laboratory setting while wearing the five devices: lying down, sitting, typing on the computer, standing, using a stationary bike at moderate and vigorous intensity, and walking on a treadmill at light and moderate intensity. Participants alternated between sedentary and active behaviors for testing, but the order in which they were completed was randomized.

The tested behaviors were standardized for all participants. Lying supine and sitting occurred on the same patient table and chair, respectively, for all participants. Participants transcribed a standardized writing prompt for the typing behavior, completing it at their own pace. Moderate-intensity cycling took place on a Monark exercise bike at 50 watts (~8 km/h) and at 70 revolutions per minute (RPM). Vigorous-intensity cycling took place at 125 watts (~20 km/h) at 70 RPMs. Low-intensity walking was performed on a treadmill at no grade, with a speed of 2.0 miles per hour (MPH). Moderate-intensity was no grade at a speed of 3.5 MPH. Participants did each behavior for five minutes, with a minimum one-minute interval break between behaviors. The order of the behaviors was randomized, alternating between the four SBs and four PAs to reduce bias of having certain behaviors completed at the beginning or end of the session. Similar protocols have been successfully used in accelerometer validation studies, including with ActiGraph devices (Carr & Mahar, 2011; Puyau et al., 2002; Treuth et al., 2004). All participants completed the assigned behaviors and received study compensation of $10 cash.

Instrumentation

ActiGraph Accelerometer. NHANES has used ActiGraph accelerometers attached to the right waist as the measurable standard in multiple waves. It is the most widely used and validated device in PA studies (Chomistek et al., 2017). In 2011, NHANES altered their measure standard of wearing the accelerometer from the right hip to placement on the non-dominant wrist, and this placement is still the current practice. Our study incorporated both a hip-based ActiGraph (Hip ActiGraph) and non-dominant wrist-based ActiGraph (Wrist ActiGraph) accelerometer to allow for comparison of the results to previous and current NHANES standards.

Activity Trackers. Although variables are called by slightly different names on activity trackers, they gather similar data. These data are recorded on the device itself and in their respective smartphone apps. For this study, activity trackers were selected based on three criteria: high popularity, smartphone connectivity and ease of app use, and wrist-based heart rate tracking capability. The number of activity trackers evaluated was limited to three so that each subject wore four activity trackers, including the Wrist ActiGraph. Having more than two devices per wrist, which increases the distance from the hand for the most proximally placed device, might alter how the device captures and interprets data; thus, selection of devices was limited despite other activity trackers meeting the criteria for testing. The three activity trackers that were selected were the Apple Watch, Basis Peak, and Fitbit Surge.

Statistical Analysis

Statistical analyses was performed using SPSS 22.0 (IBM Corp., Chicago, IL). Demographics were analyzed using simple descriptive statistics with univariate analysis. Several comparisons were made between the activity trackers and accelerometers. First, step accuracy of the three activity trackers during SB was compared to both the criterion of the Hip ActiGraph and direct observation, as no steps were observed during the SB portion of the study. The criterion of the Hip ActiGraph was used as a comparison for the PA. Second, the Wrist ActiGraph was compared to the Hip ActiGraph as a comparison of the old and current NHANES accelerometry methods. Lastly, the activity trackers were then compared to the Wrist ActiGraph.

For these comparisons, step count algorithms for each activity tracker converted raw data counts into step counts before comparisons were made. Conversion algorithms used by the different activity tracker companies are proprietary information, so this is a necessary step. It also allows for a comparison of data as it would appear in a clinical setting, presented from patient to provider. Theoretically, an alternative would be to compare raw count data. In fact, when using the Wrist ActiGraph, Kim et al. (2017) states that using the raw data might be more accurate, and therefore a better study comparison than step count.

Widely accepted norms, which have been tested for minimally important differences, for defining activity level were used, specifically the accelerometer cut points used for the 2003-2004 NHANES data, which is appropriate for the young adult population (sedentary < 100 counts/min; light, 101-2019 counts/min; moderate, 2020-5998 counts/min; vigorous, > 5999 counts/min) (Carr & Mahar, 2011; Troiano et al., 2008). The 2003-2004 NHANES data used right hip accelerometry to measure activity levels. Sedentary accuracy was calculated as percent agreement in minutes for each SB based on steps. All other data comparisons were done by correlations.

Results

A total of 50 (26 female) healthy college-aged (23.0 years, SD 2.6 years) individuals participated in and completed the assigned tasks in this study. Mean body mass index was 23.9

(SD 4.2). Ethnicity of the participants was mostly Caucasian n=41 (82%), with Asian n=4 (8%), Hispanic n=3 (6%), and Other n=2 (4%).

Figure 1 displays the step count accuracy of the ActiGraphs and activity trackers, compared to direct observation, during the sedentary tests of typing, standing, sitting, and lying down. Overall accuracy among the activity trackers during the SBs was high, with the activity trackers averaging a 97.6% accuracy. Both Apple Watch and Basis Peak averaged 99.0% accuracy, with Fitbit Surge averaging 94.9%. The Wrist ActiGraph accuracy averaged 58.6%, and the Hip ActiGraph averaged 95.1% accuracy.

The correlation between each activity tracker and the ActiGraphs during each activity is shown in Table 1. Corresponding PA step counts are represented in Figure 2. Only Apple Watch (lying, moderate walking) and Basis Peak (sitting) had significant correlations with the Hip ActiGraph. Activity trackers significantly correlate with the Wrist ActiGraph in half of all activities. No device significantly correlated with Hip or Wrist ActiGraph during typing. Wrist ActiGraph significantly correlated with Hip ActiGraph for lying, sitting, and standing behaviors only.

Table 2 shows statistically significant differences in step count between the activity trackers and the old NHANES standard (Hip ActiGraph) and the current NHANES standard (Wrist ActiGraph). On average, the activity trackers had statistically significant differences compared to the old NHANES standard in 45.8% of the SB and PAs (Apple Watch 12.5%, Basis Peak 50%, Fitbit Surge 75%). The combined average over all monitored activities compared to the current NHANES standard was 83.3% (Apple Watch 87.5%, Basis Peak 87.5%, Fitbit Surge 75%). Statistically significant differences were present 75% of the time between the old and current NHANES standards, with the Wrist ActiGraph consistently underestimating both SB and PA step count compared to the Hip ActiGraph.

Despite this high rate of statistically significant differences between the Hip and Wrist ActiGraphs, they are significantly correlated in three of the four SBs. This highlights the fact that activity trackers can be significantly different in step count, but still significantly correlated for some behaviors. These patterns can be identified by comparing table 1 to table 2. For example, Apple Watch both correlates and differs in step count with the Wrist ActiGraph in four of the eight activities.

Discussion

Accuracy of SB

This study evaluated three commercial activity trackers and how they objectively measure SB and PA behaviors in a laboratory setting. This study showed that the activity trackers studied had a high rate of accuracy among the SBs tested—94.9% or better. This means that when the participant was engaged in SB, the activity trackers studied correctly withheld accruing counts 95% of the time on a minute-by-minute basis. A similar study found that Fitbit devices underestimate SB and overestimate PA when compared to a hip-based ActiGraph (Reid et al., 2017). Another study found that the Basis Band, similar to the Basis Peak, was accurate during SB and underestimated step count with higher activity levels (Desliets & Mahar, 2016). These results are similar to the results found in this study.

This study also shows that the Wrist ActiGraph, or the current NHANES standard of measure, is significantly different in step count from the other trackers a majority of the time; it is significantly different in 13 of the 16 comparisons made in both SB and PA categories, or 81.3% of the time.

The vast step count difference seen in SB for the current NHANES standard in this study alone adds logic to the debate as to what should be the gold standard of SB measurement. Some studies note that the ActiPAL, a similar device to the ActiGraph, should be the gold standard (Byrom, Stratton, McCarthy, & Muehlhausen, 2016; Kozey-Keadle, Libertine, Lyden, Staudenmayer, & Freedson, 2011). One problem with this device is practicality. It is worn on the thigh, secured in place with a transparent dressing. Additionally, McVeigh et al. (2016) observe that SB should be defined as less than 100 counts per minute, but Kozey-Keadle et al. (2011) and Peterson et al. (2015) argue that based on activity tracker accuracy, the count threshold should be increased to 150 counts per minute.

Gomersall et al. (2016) takes a different approach, showing a "substantial" correlation if using 10,000 steps a day as a daily threshold to reduced SB. However, the 10,000 steps a day threshold would not be accurate for all people. A person who runs five miles a day, followed by eight hours of work at a desk job, would meet the active lifestyle requirements for the 10,000-step threshold while living an overall sedentary lifestyle, and research shows that PA does not overcome the negative effects of long SB (Diaz et al., 2017; Peterson, Sirard, Kulbok, DeBoer, & Erickson, in press).

Accuracy of PA

Biking. This study showed that the activity trackers and ActiGraphs underestimated activity level, based on a low reported-step count, during moderate and vigorous biking. The low step count measured during the biking activities in this study correlated with findings of another study, in which wrist-based accelerometers were shown to have a poor ability to properly identify the correct physical activity level (Rosenberger et al., 2013).

Walking. This study also found that the Apple Watch, Basis Peak, and Fitbit Surge activity trackers overestimated step count during light walking PA compared to the ActiGraph, which complements the findings of other studies (Gomersall et al., 2016; Reid et al., 2017). In contrast, Diaz et al. (2015) found that Fitbit is just as accurate as ActiGraph in measuring step count.

NHANES standards

This study shows that the Wrist ActiGraph consistently underestimates step count compared the Hip ActiGraph, showing a statistical difference between the two 75% of the time. Rosenberger et al. (2013) had similar findings when using a wrist-based ActiGraph, but they emphasized that despite these findings, compliance is a major factor. People are more willing to wear a wrist-based device over a hip-based device, which could be a contributing factor why NHANES converted to the Wrist ActiGraph as the new standard of measure.

Another point to consider is if an adjustment to the step count algorithm of the Wrist ActiGraph is made, making it more sensitive to movement, the significant step count differences would be eliminated. This is only considered due to the high correlation rate combined with a high significant step count difference between the Wrist ActiGraph and other devices.

Overall Stance on Activity Trackers

Activity trackers can be an effective tool for monitoring both SB and PA (Reid et al., 2017; Gomersall et al., 2016). With new research continually emerging on the deleterious effects of SB, it is becoming crucial for healthcare providers to have a way to monitor SB in their patients (Diaz et al., 2017).

Numerous organizations have outlined ways to promote PA and discourage SB, such as the CDC and WHO, and more information can be found on their respective websites. Another resource can be found at exerciseismedicine.org, an organization focused on ways to blend healthcare with PA. When combined with PA and SB information gained from activity trackers, these resources can help healthcare PCPs provide personalized, patient-centered quality healthcare.

When looked at from a global perspective, the activity trackers studied statistically correlated in step count with the ActiGraphs 31.3% of the time, and statistically differed in step count 64.6% of the time. As technology continues to advance and newer models of activity trackers emerge, these statistics will improve, as long as researchers continue to evaluate these trackers.

Limitations

Only healthy young adults participated in this study, so findings cannot be generalized to other populations. This study compared each activity tracker's individualized step counts rather than analyzing the raw data fields. As discovered in other studies, this could have an effect on the findings reported.

Conclusions

The purpose of this study was to evaluate three commercial activity trackers with young adults in a laboratory setting regarding how they objectively measure SB and PA behaviors compared to the ActiGraph accelerometer device on the previous and current NHANES standards of hip and wrist, respectively. Overall accuracy during all sedentary behaviors was high, performing similar to the Hip ActiGraph and markedly better than the Wrist ActiGraph. All activity trackers had significant correlations with Wrist ActiGraph during PA. While some variability is seen in the validity of the activity trackers, each activity tracker studied has its own strengths and weaknesses. Understanding these limitations helps healthcare professionals more accurately interpret recorded data based on the patient specific device.

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Appendix A.

Physical Activity Readiness Questionnaire

1) Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?

2) Do you feel pain in your chest when you do physical activity?

3) In the past month, have you had chest pain when you were not doing physical activity?

4) Do you lose your balance because of dizziness or do you ever lose consciousness?

5) Do you have a bone or joint problem that could be made worse by a change in your physical activity?

6) Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?

7) Do you know of any other reason why you should not do physical activity?

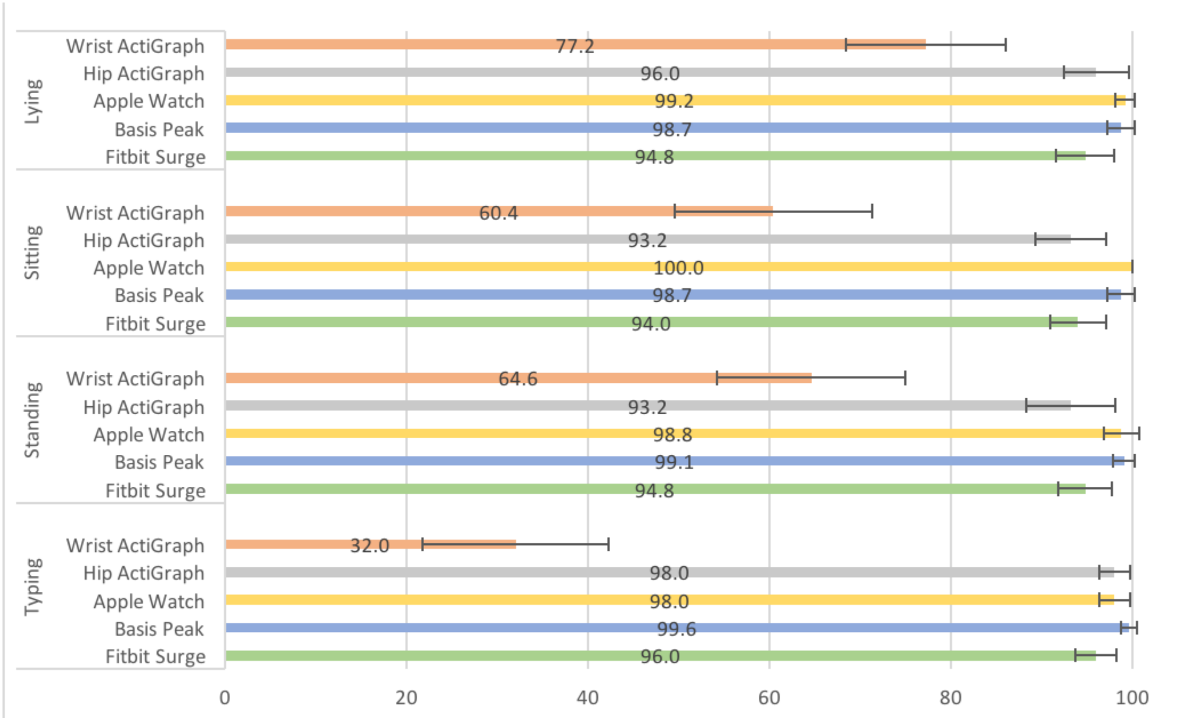

Figure 1. Sedentary steps correct (percent)

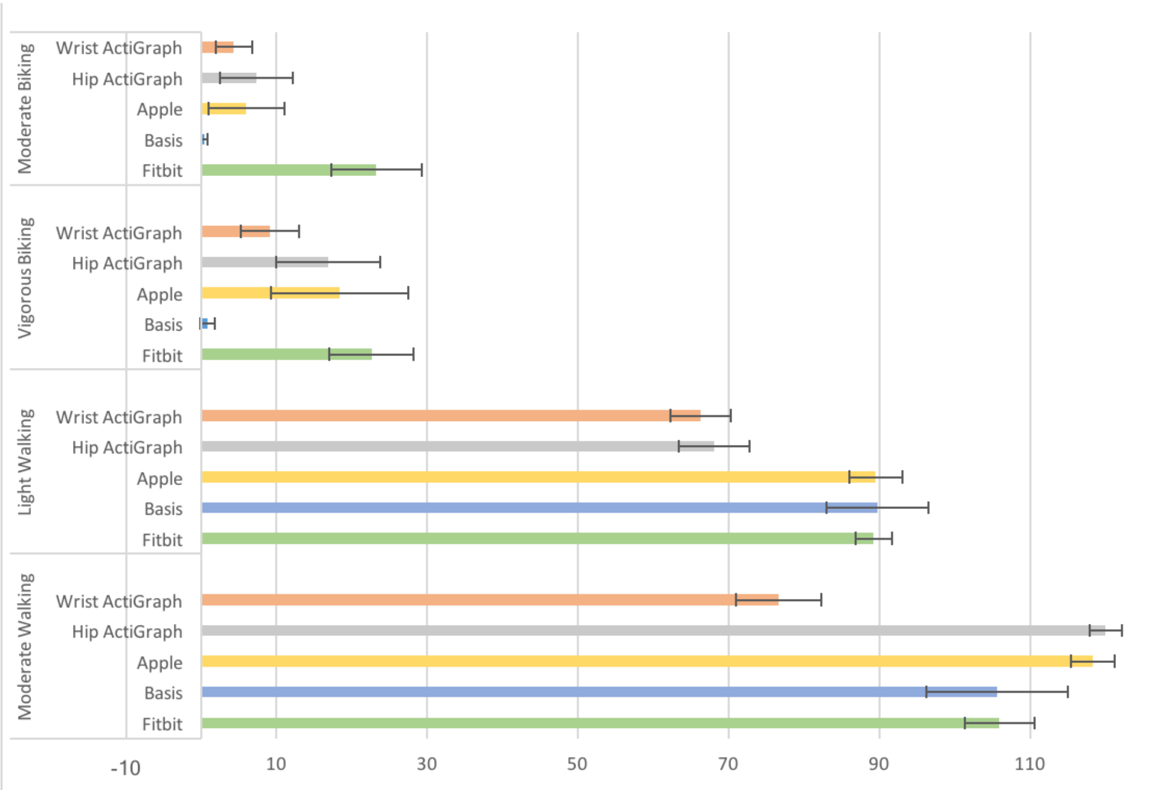

Figure 2. Active steps per minute

Table 1. *Correlation to ActiGraph*

Correlation to ActiGraph (AG) by activity				Correlation to ActiGraph (AG) by device			
Activity	**Device**	**Hip AG *r*(*p*)**	**Wrist AG *r*(*p*)**	**Device**	**Activity**	**Hip AG *r*(*p*)**	**Wrist AG *r*(*p*)**
Lying	Wrist AG	0.50 (0.00)		**Wrist AG**	Lying	0.50 (0.00)	
	Hip AG		0.50 (0.00)		Sitting	0.76 (0.00)	
	Apple	0.32 (0.03)	0.83 (0.00)		Standing	0.46 (0.00)	
	Basis Peak	0.02 (0.90)	0.12 (0.42)		Typing	0.01 (0.93)	
	FitBit Surge	-0.11 (0.45)	-0.12 (0.43)		Mod Bike	0.03 (0.86)	
					Vig Bike	0.06 (0.71)	
Sitting	Wrist AG	0.76 (0.00)			Light Walk	0.15 (0.33)	
	Hip AG		0.76 (0.00)		Mod Walk	0.09 (0.54)	
	Apple	-0.04 (0.79)	-0.11 (0.48)				
	Basis Peak	0.68 (0.00)	0.40 (0.01)	**Hip AG**	Lying		0.50 (0.00)
	FitBit Surge	-0.09 (0.54)	-0.05 (0.75)		Sitting		0.76 (0.00)
					Standing		0.46 (0.00)
Standing	Wrist AG	0.46 (0.00)			Typing		0.01 (0.93)
	Hip AG		0.46 (0.00)		Mod Bike		0.03 (0.86)
	Apple	0.07 (0.66)	0.34 (0.02)		Vig Bike		0.06 (0.71)
	Basis Peak	-0.06 (0.68)	0.13 (0.40)		Light Walk		0.15 (0.33)
	FitBit Surge	0.12 (0.44)	0.37 (0.01)		Mod Walk		0.09 (0.54)
Typing	Wrist AG	0.01 (0.93)		**Apple**	Lying	0.32 (0.03)	0.83 (0.00)
	Hip AG		0.01 (0.93)	**Watch**	Sitting	-0.04 (0.79)	-0.11 (0.48)
	Apple	0.07 (0.65)	0.26 (0.08)		Standing	0.07 (0.66)	0.34 (0.02)
	Basis Peak	0.25 (0.10)	-0.05 (0.73)		Typing	0.07 (0.65)	0.26 (0.08)
	FitBit Surge	-0.04 (0.80)	-0.03 (0.84)		Mod Bike	0.19 (0.21)	0.75 (0.00)
					Vig Bike	0.27 (0.07)	0.63 (0.00)
Moderate	Wrist AG	0.03 (0.86)			Light Walk	0.03 (0.82)	0.61 (0.00)
Biking	Hip AG		0.03 (0.86)		Mod Walk	0.51 (0.00)	0.20 (0.19)
	Apple	0.19 (0.21)	0.74 (0.00)				
	Basis Peak	-0.10 (0.53)	0.66 (0.00)	**Basis**	Lying	0.02 (0.90)	0.12 (0.42)
	FitBit Surge	-0.11 (0.46)	0.10 (0.52)	**Peak**	Sitting	0.68 (0.00)	0.40 (0.01)
					Standing	-0.06 (0.68)	0.13 (0.40)
Vigorous	Wrist AG	0.06 (0.71)			Typing	0.25 (0.10)	-0.05 (0.73)
Biking	Hip AG		0.06 (0.71)		Mod Bike	-0.10 (0.53)	0.66 (0.00)
	Apple	0.27 (0.07)	0.63 (0.00)		Vig Bike	0.10 (0.51)	0.31 (0.04)
	Basis Peak	0.10 (0.51)	0.31 (0.04)		Light Walk	0.22 (0.15)	0.37 (0.01)
	FitBit Surge	-0.03 (0.85)	-0.03 (0.83)		Mod Walk	-0.08 (0.62)	0.03 (0.85)
Light	Wrist AG	0.15 (0.33)		**Fitbit**	Lying	-0.11 (0.45)	-0.12 (0.43)
Walking	Hip AG		0.15 (0.33)	**Surge**	Sitting	-0.09 (0.54)	-0.05 (0.75)
	Apple	0.03 (0.82)	0.61 (0.00)		Standing	0.12 (0.44)	0.37 (0.01)
	Basis Peak	0.22 (0.15)	0.37 (0.01)		Typing	-0.04 (0.80)	-0.03 (0.84)
	FitBit Surge	-0.05 (0.74)	0.48 (0.00)		Mod Bike	-0.11 (0.46)	0.10 (0.52)
					Vig Bike	-0.03 (0.85)	-0.03 (0.83)
Moderate	Wrist AG	0.10 (0.54)			Light Walk	-0.05 (0.74)	0.48 (0.00)
Walking	Hip AG		0.10 (0.54)		Mod Walk	-0.03 (0.87)	0.39 (0.01)
	Apple	0.51 (0.00)	0.20 (0.19)				
	Basis Peak	-0.08 (0.62)	0.03 (0.85)				
	FitBit Surge	-0.03 (0.87)	0.39 (0.01)				

Note. Highlighted values represent statistical significance of $p \leq 0.05$. AG = ActiGraph, Mod = Moderate Biking, Vig = Vigorous

Table 2. *Step Count Difference to NHANES*

Step count difference to NHANES standard by activity				**Step count difference to NHANES standard by device**			
Activity	**Device**	**OLD (*p*)**	**CURRENT (*p*)**	**Device**	**Activity**	**OLD (*p*)**	**CURRENT (*p*)**
Lying	Wrist AG	0.01		**Wrist AG**	Lying	0.01	
	Hip AG		0.01		Sitting	0.00	
	Apple	0.48	0.01		Standing	0.00	
	Basis Peak	0.33	0.06		Typing	0.00	
	Fitbit Surge	0.01	0.010		Mod Bike	0.18	
					Vig Bike	0.03	
Sitting	Wrist AG	0.00			Light Walk	0.42	
	Hip AG		0.00		Mod Walk	0.00	
	Apple	0.07	0.00				
	Basis Peak	0.60	0.00	**Hip AG**	Lying		0.01
	Fitbit Surge	0.00	0.04		Sitting		0.00
					Standing		0.00
Standing	Wrist AG	0.00			Typing		0.00
	Hip AG		0.00		Mod Bike		0.18
	Apple	0.87	0.00		Vig Bike		0.03
	Basis Peak	0.32	0.00		Light Walk		0.42
	Fitbit Surge	0.08	0.05		Mod Walk		0.00
Typing	Wrist AG	0.00		**Apple Watch**	Lying	0.48	0.00
	Hip AG		0.00		Sitting	0.07	0.00
	Apple	0.10	0.00		Standing	0.87	0.00
	Basis Peak	0.64	0.00		Typing	0.10	0.00
	Fitbit Surge	0.01	0.14		Mod Bike	0.58	0.32
					Vig Bike	0.92	0.02
Moderate Biking	Wrist AG	0.18			Light Walk	0.00	0.00
	Hip AG		0.18		Mod Walk	0.30	0.00
	Apple	0.56	0.32				
	Basis Peak	0.01	0.00	**Basis Peak**	Lying	0.33	0.06
	Fitbit Surge	0.00	0.00		Sitting	0.60	0.00
					Standing	0.32	0.00
Vigorous Biking	Wrist AG	0.03			Typing	0.64	0.00
	Hip AG		0.03		Mod Bike	0.01	0.00
	Apple	0.92	0.02		Vig Bike	0.00	0.00
	Basis Peak	0.00	0.00		Light Walk	0.00	0.00
	Fitbit Surge	0.29	0.00		Mod Walk	0.01	0.00
Light Walking	Wrist AG	0.42		**Fitbit Surge**	Lying	0.01	0.10
	Hip AG		0.42		Sitting	0.00	0.04
	Apple	0.00	0.00		Standing	0.08	0.05
	Basis Peak	0.00	0.00		Typing	0.01	0.14
	Fitbit Surge	0.00	0.00		Mod Bike	0.00	0.00
					Vig Bike	0.29	0.00
Moderate Walking	Wrist AG	0.00			Light Walk	0.00	0.00
	Hip AG		0.00		Mod Walk	0.00	0.00
	Apple	0.30	0.00				
	Basis Peak	0.01	0.00				
	Fitbit Surge	0.00	0.00				

Note. Highlighted values represent statistical significance of $p \leq 0.05$. AG = ActiGraph, Mod = Moderate Biking, Vig = Vigorous