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The Comparison of Using the Preferred or Non-Preferred Wrist When Measuring Physical Activity in College Students

Bryce Daniels
University of Arkansas, Fayetteville

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by

Bryce Daniels
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Erin K Howie, Ph.D
Thesis Director

Kaitlin Gallagher, Ph.D
Committee Member

Michelle Gray, Ph.D
Committee Member

Abstract

Introduction. People who participate in regular physical activity have a decreased risk of chronic diseases and premature death. A dramatic decrease of physical activity occurs from adolescence to young adulthood. With important implications to health, physical activity is an important behavior to measure. However, inconsistencies exist on how to measure physical activity. When using accelerometers, differences between the preferred or non-preferred wrist may result in different estimates of physical activity. **Purpose.** The purpose of this study was to compare the preferred and non-preferred wrist accelerometry measured physical activity using commonly used research accelerometers during structured daily college activities (Actigraph GT3x-bt and GT9X Link) and free-living conditions of college students (Actigraph GT9X Link). **Methods**: 30 college students (15 females and 15 males) completed 7 laboratory tasks including shooting a basketball (BB), relaxing on a couch (Relax), hitting a racquetball (RB), walking up and down stairs (WUS), walking on an inclined surface (WUI), walking while using a smart phone (WSP), and using a laptop (COM). An Actigraph GT3x-bt and Actigraph Link on each wrist and the right hip. After the tasks, the students completed one week of free-living conditions wearing an Actigraph Link on each wrist. Accelerometer counts from the preferred and non-preferred wrists were compared using *Wilcoxon signed-rank tests* for the lab activities and a paired t tests for the free-living conditions with α at .05. **Results:** Preferred and non-preferred total counts per minute from the Actigraph Link were significantly different for BB (p= <.001), COM (p=.004), RB (p= <.001), Relax (p=.027), WSP (p=.001), and WUS (p=.043). The free-living conditions showed no significant differences between the preferred and non-preferred wrist. **Conclusion.** Researchers should be aware when measuring physical activity in structured activities that the preferred and non-preferred wrist can affect the measurement. Though for free living conditions, less concern should be placed on the preferred or preferred wrist.

Acknowledgment

LET’S GO!!!!!! It is done!!!!!!! I want to acknowledge the good Lord who was with me every step of the way. I want to acknowledge His blessings that came in the form of an amazing supporting cast including a loving family, incredible friends, the best dadgum thesis committee on campus, my wise/plentiful mentors, and finally my humbling participants. Everyone played pivotal roles in the completion of this document and helping me get another degree. The above list all put the “STUD” in my study. Oh yeah almost forgot, exercising and ice cream helped too.

Dedication

I dedicate this to those who see challenges as adventures and to those who never let probability interfere with their ambition or dreams.

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Introduction

Physical activity is considered any bodily movement caused by skeletal muscles resulting in energy expenditure (Caspersen, Powell, & Christenson, 1985). The relationship between physical activity (PA) and health benefits have been well documented (Reiner, Niermann, Jekauc, & Wolf, 2013). For example, the volume of PA and health status have consistently shown to have a negative linear relationship, where more physically active people, including children, have a lesser risk for chronic diseases and premature death (Warburton, 2006). This critical correlation has driven increased efforts of exercise scientists, public health researchers, and even the general population itself to measure routine, physical activity.

In recent years, researchers have adopted and widely accepted accelerometry as a means of measuring PA with significant improvement over self-report methodologies (Denckner & Andersen, 2008; Kohl, Fulton, & Caspersen, 2000; Trost, 2001; Van Cauwenbreghe, Valery, Trost, de Bourdeaudhuij, & Cardon, 2010). Two important components of accelerometry are the accelerometer itself (the model, hardware, and software) and the accelerometer's location on the human body. The Actigraph GT3X/GT3x-bt can be considered a criterion measure for physical activity expressing high validity when compared to measured oxygen consumption estimated energy expenditure (Kelly et al, 2013). The GT3x-bt are triaxial accelerometers, though studies previously used uniaxial acceleration sensors. A triaxial accelerometer can measure accelerative forces across three planes of motion including the vertical, anteroposterior, and medial-lateral planes and produce inclinometer output, while the acceleration sensor measures static and dynamic accelerations (Kelly et al, 2013). A new model, the Acitgraph GT9X Link, was released in November of 2014, with the main difference from the GT3x-bt being the Link has a screen, weighs less, and has a smaller shape. The manufacturer asserts that the models are interchangeable with the older models; however, there is a lack of studies validating the new product.

Moreover, traditionally, the hip was considered the gold standard for placement of an accelerometer (Troiano et al., 2008; Rosenburger et al., 2013). The National Health and Nutrition Survey (NHANES) 2003-2004 implemented hip placement in its protocol. Resenburger et al. (2013) reports the hip position provides the most valid placement for estimating energy expenditure. However, placement at the hip has had deficient compliance with wearing the accelerometer throughout a monitoring period (Belton, O'Brien, Wickel, & Issartel, 2013). To attempt to improve compliance, recent studies have investigated accelerometer placement on the wrist. Wrist accelerometry was thought to be limited in accuracy of the measured PA compared to the hip position (Swartz et al., 2000), although the study only used uniaxial accelerometers and compared counts which were used to establish cutpoints for different exercise intensities. Recent studies convey that features from triaxial raw accelerometer signal have increased the accuracy between PA energy expenditure estimates of the wrist position when compared to the hip position and a valid placement for measuring PA (Eliger et al., 2011; Phillips, Parfitt, & Rowlands, 2013). Also, NHANES 2013-2014 revealed the protocol shifted to wrist placement (using the GT3x-bt), noting that the wrist is advantageous in increased wear time compliance and the ability to assess sleep (Troiano, McClain, Brychta, & Chen, 2014). These data, however, have not been released. Though new, wrist accelerometry has been recognized as a valid placement measuring physical activity and thus, used in studies as a means of measuring PA. However, there have been limited studies directly comparing wrist to waist placement, particularly in young adults.

Using hip worn accelerometers and self-reported measures, PA levels have been assessed among different age groups across the life span. Aaron et al. (2002) announce that the most dramatic decline in physical activity occurs during adolescence (ages 15 to 18) to young adulthood (ages 20 to 25). This drop in PA levels is a complex issue explained by a variety of factors such as working (time availability), family commitments, and life events. Another possible explanation includes higher education enrollment. A total of 46 % to 52.3% of college students have self-reported being inactive with irregular exercise (Wallace, Buckworth, Kirby, & Sherman, 2000; Pinto & Marcus 1995). Studies show that PA measured in college students with accelerometry reported significantly lower objectively measured PA compared to self-reported data (Downs, Van Hoomissen, Lafrenz, & Julka, 2014). Self-report was a common methodology that the majority of PA research in the young adult population utilized (Sallis & Salens, 2000). This is problematic though, as Johnson and Richter (2004) report that individuals are susceptible to self-bias which leads subjects to naturally overestimate the degree to which they possess desirable traits or engage in desirable behavior. Importantly, most college students felt an increase in feeling of guilt and shame associated with not being physically active (Ullrich-French, Cox, & Bumpus, 2013). To avoid this perceived guilt and shame, college students may be more susceptible to overestimating PA levels. Thus, subjective data can be more prone to bias. Utilizing accelerometers, an objective measure of PA, for college students will more accurately measure patterns of physical activity and their associations with health, which ultimately can be used to improve PA habits and health.

According to Bureau of Labor Statistics (2016), college students from 2011-2015 were spending an average of 3.5 hours per day on educational activities and 4.0 hours per day on leisure and sports. This suggests an average college student spends over 50% (excluding one hour for eating and drinking) of his or her waking hour activities involved in educational or leisure activities, while the remaining waking hours go toward activities such as working, grooming, traveling, and “other.” These data, however, is missing a recent development in time use for college students – mobile device usage, and particularly cell phone usage. It is important to note that the iPad and iPhone were both released before this study as the iPad was released in 2010 and the iPhone was released in 2007 both of which were released before this study. A study showed that the average time spent on a cell phone (for all uses except listening to music) of a university student includes a mean of 380 minutes per day, with 70% of that time associated with leisure (Barkley & Lepp, 2016). Daily activities for college students encompass a mixture of physical and sedentary activities pertaining to education, including walking to class, sitting in lecture, and studying as well as participating in leisure activities, such as shooting a basketball, watching TV, or using their cell phone. For ecological validity, common activities of college students should be assessed when investigating college students’ PA, including mobile technology use. Studies have evaluated college students’ PA in free living situations using accelerometry (Dinger & Behrens, 2006). However, when using an accelerometer at the wrist, studies have shown mixed protocols for whether an accelerometer should be placed on the dominant wrist or non-dominant wrist (Toriano et al, 2014; Crouter, Flynn, & Bassett, 2015). Wrist placement may detect different movements when using mobile technology. For example, the growing use of phones and tablets can be more susceptible to wrist placement measured PA as opposed to the hip. Limited research has been performed to compare the non-dominant and dominant wrist when measuring physical activity.

For the purposes of this research, preferred is the term used to describe which arm most typically used to complete daily activities such as writing, brushing your teeth, using a fork and so forth. It should be noted that the title “dominant” might be used synonomously with preferred. However, the dominant arm does not have to be the preferred arm when performing daily life activities. Having a preferred arm could potentially be problematic to accurately measuring PA if people perform tasks with their preferred arm as opposed to their other arm. Potentially, one arm might be preferred because it can produce both higher and more accelerative forces over time than the other arm, especially in a preferred-arm driven task, such as swinging a racquet. However, one study concluded that non-dominant or dominant wrist placement does not have a significant difference when measuring PA of sedentary, household, walking, and running activities (Zhang, Rowlands, Murray, & Hurst, 2012). The sample in the previous study, however, did not include college students who as a population participate in different common activities. It was also limited in that it involved only structured activities. Not having a free-living condition limited the study by not truly depicting a subject’s PA habits outside the lab. A single lab performance is unlikely representative as compared with what a subject does in his or her everyday life.

Using a 24-hr free living protocol, Dieu et al. (2015) found no significant differences between the dominant and non-dominant wrist placements. Participants only participated in a 24-hour free living data collection protocol. Having no structured activities and only monitoring the free-living condition for 24 hours limits the study. The researchers had no control of what physical activities, if any, were performed. Also, 24 hours is arguably not enough time to get a true sense of a subject’s PA. Physical activity, particularly exercise, is an episodic activity that may not regularly occur during a 24 hour period. Perhaps a subject who is normally physically active was not on the day of collection, potentially creating data not representative of the subject’s true PA patterns. Multiple days of wear are required to obtain reliable estimates of habitual physical activity (McClain, Sission, & Tudor-Locke, 2007).

Lastly, De Man et al. (2016) reported that step counts collected from two commercial accelerometers were not significantly different when worn on the dominant and non-dominant wrists (De Man et al., 2016). This study was limited by only including six participants and not all the data from every participant could be analyzed. This study also only looked at walking and step counts as a measure of PA. Analyzing only walking as a structured activity, with only six participants, does not represent a variety of movements encountered in daily life when comparing PA measures of the non-dominant and dominant wrist. With physical activity levels having pragmatic correlations to health outcomes, it is necessary to compare measured PA at both wrists during common college activities to investigate the accuracy of PA measurements for college students.

Purpose of the study

The purpose of this study was to compare the preferred and non-preferred wrist accelerometry measured physical activity using commonly used research accelerometers during structured daily college activities (Actigraph GT3x-bt and GT9X Link) and free-living conditions of college students (Actigraph GT9X Link). The study will also assess the validity of the Actigraph GT9X Link compared to the Actigraph GT3x-bt both on the wrist and the hip.

Hypotheses

This study examined the following hypotheses:

1) Mean counts per minute (CPM) will not be significantly different between the preferred and non-preferred wrist sites within device for the X, Y, Z axes and mean

total counts per minute (tCPM) over the time participants are performing each activity of the lab (Actigraph GT9X Link and GT3x-bt) and free-living conditions (GT9X Link).

2) Mean counts per minute of the X, Y, Z axes and mean tCPM of the Actigraph GT9X Link will not be significantly different from the Actigraph GT3x-bt within the preferred wrists, non-preferred wrists, and the right hip sites over the time participants are performing each lab activity.
3) Mean counts per minute from the Actigraph GT9X Link on the preferred and non-preferred wrists will be positively correlated for the free-living condition and positively correlated to the hip over the time they are performing each activity of the lab.

Methodology

Research Design

This study implemented an experimental and observational design by comparing results of accelerometers worn on preferred and non-preferred wrists during structured, laboratory conditions and free-living or unstructured conditions.

Participants

Participants of a convenience sample were comprised of 30 volunteers (15 male and 15 female) in the age range of 18 to 25 years from the University of Arkansas. Referrals and snowball sampling via word of mouth were the main forms of recruitment. Eligibility requirements for participants included: no current injuries, limitations with limbs, or movement limitations, and must own a smart phone. The study received approval from the Institutional Review Board at the University of Arkansas (Appendix A). Participants provided informed written consent prior to participation in the study (Appendix B).

Measures/Instrumentation

Familiarization and Exposures. Participants were asked to fill out a physical activity questionnaire, short form International Physical Activity Questionnaire (IPAQ) (Appendix C). The short form IPAQ is considered a valid surveillance tool for assessing PA levels and patterns of healthy adults (Craig et al., 2007). The short form IPAQ was used to get a sense of familiarization of the subject's PA habits going into the study and to provide additional context to the objectively measured physical activity. Anthropometric measures including height and weight were taken using a stadiometer and platform scale, respectively. These measurements were used to calculate the participant's body mass index (BMI). Each participant identified his or her preferred arm, the arm of which the participant uses when completing most tasks, when performing tasks of daily living activities.

Physical Activity Outcomes/Instrumentation. The physical activity outcomes included mean counts per minute (CPM) of the X-Axis, Y-Axis, Z-Axis and mean total counts per minute across all three axes (CPM). Mean counts per minute is the unit of accelerometry that represents the raw accelerative forces measured by the accelerometer (Troiano et al., 2008). There were a total of 6 accelerometers covering four locations during the laboratory conditions and two accelerometers during the free-living condition. The comparisons being made can be found in Table 1. An Actigraph GT3x-bt and Actigraph GT9X Link were placed on both the subject's wrists, side by side in consistent order with the GT3x-bt distal and closer to the wrist joint, as well as on the subject's right hip. Refer to Figure 1 to see the different axis orientation of the devices on the wrist (note the orientation of the axes on the hip were the same for both devices) and Figure 2 to see the axis orientations on the hip. The right hip was chosen due to previous research establishing its high correlation with energy expenditure (Rosenburger et al., 2013). The accelerometers were used to track the physical activity during structured conditions and free-living conditions to investigate the significant differences of physical activity measured between the accelerometers on the preferred and non-preferred wrists. The structured conditions were compared to the unstructured conditions to ensure reliability of physical activity patterns.

Table 1

Summary of the Comparisons Being Made in the Study

Comparison	Accelerometer (Actigraph) Used or Location	Condition	Analysis
Preferred Wrist vs Other Wrist	GT9X Link GT3x-bt	Lab & Free Living Lab only	T test between site
Actigraph GT3x-bt vs GT9X Link	All Three Sites	Lab only	T-test between device
Both Wrists vs Hip	GT9X Link GT3x-bt	Lab only	Correlation between sites

Figure 1. A picture of the Link (left) and GT3x-bt (right) and their axes on the wrist.

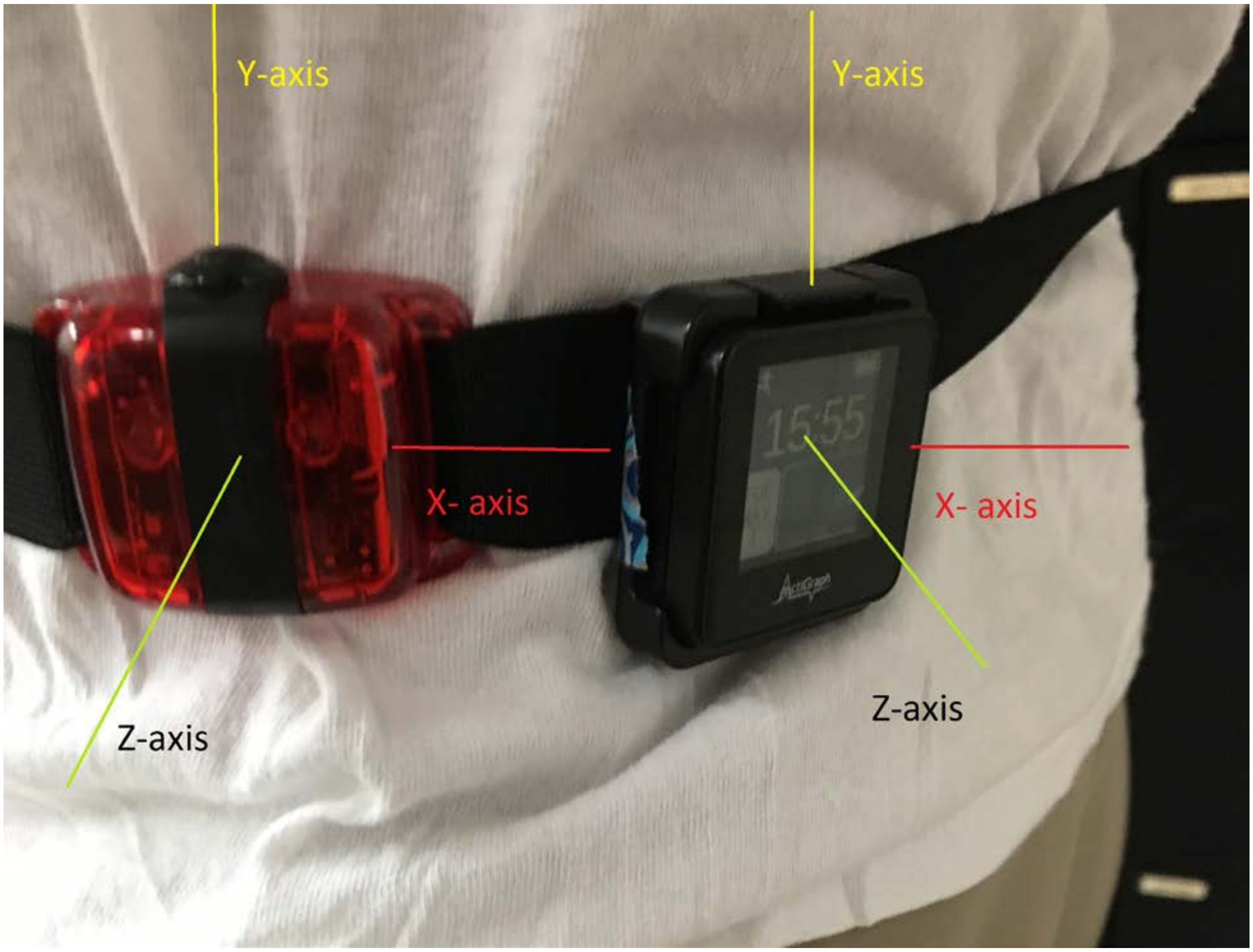

Figure 2. A picture of the GT3x-bt (left) and Link (right) and axes orientation while on the hip.

Task Instrumentation. All lab activities took place inside the University of Arkansas' Health Physical Recreation, and Recreation Building (HPER). The order of the lab activities was randomized. A 200-meter track and the participant's cell phone were utilized to complete the cell phone use (texting, surfing the internet, looking at social media) while walking task (WSP). Four flights of stairs were used to complete the walking up and down stairs tasks (WUS). A treadmill, set at an incline of 4% grade, was utilized to perform walking up an inclined surface (WUI). A desk and laptop were provided for homework/study time (COM). A TV, couch, and cell phone were also used to complete the task of relaxing (Relax). A basketball, and half a basketball court, were used while the subject shot a basketball and person rebounded the basketball (BB). A racquetball racquet, a racquetball, and a racquetball court were used to hit a racquetball (RB).

Procedures

Participants came to the Exercise Science Research Center for one visit. After the visit, the participant returned after 7 days to allow time for free-living conditions and to return the equipment. Participants were asked to wear athletic clothes, tennis shoes, and to bring their smart phones. At the visit, each participant was asked to complete the short form IPAQ. Height and weight was measured, preferred arm was recorded, and BMI was calculated. Upon completion of the familiarization, the subject wore the accelerometers in the appropriate locations, including the preferred and other wrists, and right hip. Then, the participant was asked to perform the following described common activities of college students. All measurements and notes were recorded by the research assistant (Appendix D).

Lab Condition. Each activity was performed for 8 minutes, with a 1-2-minute break between each activity. Activities include walking while using a smart phone on a track at a self-selected speed, walking up and down flights of stairs (self-selected speed), walking on an inclined surface (treadmill) (self-selected speed), studying or completing homework on a computer, watching TV or playing on their phone, shooting a basketball, and hitting a racquetball. Each subject was asked to perform the tasks as he or she normally would. The Actigraph GT3x-bt's were removed and the Acitigrah GT9X Links were switched out to allow the data to be transferred to the computer, and the subject immediately began the free-living condition. The left wrist Link was denoted by a piece of tape. A research assistant supervised all activities and took detailed notes.

Free Living Condition. During the free-living condition, participants were asked to live their lives as they normally would and instructed to wear the two Actigraph GT9X Links, one on their preferred wrist and one on the other wrist, for 24 hours per day, excluding water-based activities. Subjects kept a log of any non-wear times (Appendix C), such as bathing and swimming, and recorded lights out and wake times (lights out time is the time where participants turn out their lights to attempt to start falling asleep). Reminder text messages were sent once or twice during the week. At the end of 7 days, the subject was reminded via text to return to the lab, so the accelerometers could be returned. The data were processed using Actilife 6.13.3 Software (Troaino et al, 2008).

Data Analysis

All recorded data were held confidential. To investigate differences between the preferred and non-preferred wrists, the count per minute (CPM) data files (60 second epoch) were processed and output from Actilife (6.13.3) software as minute-by-minute .csv files were matched between concurrent preferred wrist and non-preferred wrist assessments using time the activity started or ended in the lab. Time and date codes were used when processing the free-living data. Mean CPM were calculated over the six of the eight minutes they were performing each lab activity in the X, Y, and Z axes along with average tCPM for each device. The first minute and the last minute of each activity was not used in the data processing to allow for partial minutes of performing the prescribed activity. For the free-living condition, mean CPM were calculated daily for and X, Y, and Z axes and average tCPM for 8 days the time the accelerometer was used.

Descriptive statistics were examined and normality was checked by evaluating histograms, skewness and kurtosis and Shapiro-Wilk tests using StataIC 15. The daily means for the free-living data were normally distributed while the lab data were non-normal and appropriate non-parametric tests were used. For Hypothesis One, a *Wilcoxon signed-rank test* was used to test the difference between the mean counts per minute of the preferred wrist against the non-preferred wrist separately for each activity. For the free-living condition, a *t* test to compare the difference in the mean counts per minute between the preferred and non-preferred wrists for the 7 days for the time the accelerometer was worn. To test Hypothesis Two, a *Wilcoxon signed-rank test* to compare the Actigraph GT3X's and Actigraph GT9X Link's for each anatomical site was used to compare mean counts per minute separately for each activity. For Hypothesis Three, individual Spearman correlations between the preferred and non-preferred counts per minute were calculated for each individual for the 8 days of free living data. Mean, standard deviation and ranges were calculated. Gender, age, IPAQ vigorous minutes per week and total METs, BMI, preferred handedness, and total counts per minute were used to investigate the effects of potential covariates using *t* tests or *Wilcoxon signed-rank tests* for categorical variables and Spearman correlations for continuous variables. Spearman correlations between the preferred wrist and hip as well as the non-preferred wrist and hip were also calculated. For all *t* tests and *Wilcoxon signed-rank tests*, significance was set to $p < .05$. As this was an exploratory study, no adjustments were made for multiple comparisons.

Results

Descriptive Statistics of the Sample

Refer to Table 2 for the descriptive statistics for the study's sample including the means and standard deviations of height (in), weight (lbs), BMI, age (years), Vigorous Activity Total (min/week), Moderate Activity Total (min/week), and Walk Total (min/week).

Table 2

Summary of the Sample's Anthropometric Measures and Self-Reported Physical Activity

Category	Mean (sd)
Height (in)	67.5 (4.3)
Weight (lbs)	165.7 (31.3)
BMI	25.3 (3.4)
Age (years)	21.4 (1.9)
Vigorous Activity Total (min/week)	189.8 (193.9)
Moderate Activity Total (min/week)	213 (262.3)
Walk Total	417.9 (385.3)

Hypothesis One

Hypothesis One suggested mean counts per minute of the Actigraph GT9X Link and GT3x-bt would not be significantly different between the preferred and non-preferred wrists sites within device of the X, Y, Z axes and mean total counts per minute over the time participants were performing each activity (Total) of the lab and free-living conditions. Contrary to

Hypothesis One, significant differences of mean CPM of Actigraph GT9X Link were found between the preferred and non-preferred wrists sites over the time participants were performing each lab activity.

Preferred vs Non-Preferred Actigraph Link Lab Activity Results

Activities that showed statistical differences of the X-axis include COM (p= .019), RB (p=.014) and WSP (p= <.001). Statistical differences in activities of the Y-axis include BB (p= <.001), COM (p= .005), RB (p= 0.045), and WSP (p= <.001). Statistical differences in activities of the Z-axis include BB (p=.039), COM (p= .037), RB (p= <.001), Relax (p= .022), WSP (p= .006), and WUS (p=.003). Statistical differences in activities of tCPM include BB (p= .010), COM (p= .004), RB (p= <.001), Relax (p= .037), WUS (p= .009), and WSP (p= <.001). COM, RB, and WSP were the only activities with significantly differences across all axes and total CPM. Means and standard deviations for each activity can be found in Table 3.

Table 3

Summary of the Actigraph Link Lab Activities Results

	Link											
	X-axis			Y-axis			Z-axis			Tcpm		
	Preferred	Non-Preferred	p-value[a]	Preferred	Non-Preferred	p-value[a]	Preferred	Non-Preferred	p-value[a]	Preferred	Non-Preferred	p-value[a]
BB	11,779.4 (1,895.3)	11,325.1 (3,045.1)	.643	20,371.4 (24,607.5)	13,900.9 (2,565.8)	**<.001**	10,324.6 (1,638.0)	9,462.8 (1,969.7)	**.039**	37,624.1 (5,194.6)	35,078.9 (5,420.0)	**.010**
COM	361.2 (352.6)	443.4 (247.8)	**.019**	351.7 (334.3)	470.4 (295.4)	**.005**	488.6 (422.1)	608.4 (386.5)	**.037**	1,183.4 (1,077.2)	1,522.0 (884.7)	**.004**
RB	7344.3 (1072.5)	6,812.2 (1942.5)	**.014**	10,344.1 (1,941.3)	7609.2 (2,157.8)	**<.001**	8,217.3 (1,343.2)	6,261.8 (1,583.1)	**<.001**	25,719.0 (4,318.3)	20,715.8 (5,405.3)	**<.001**
Relax	469.0 (421.0)	661.9 (546.1)	.086	317.4 (264.0)	449.8 (409.4)	.084	505.5 (405.0)	690.5 (520.2)	**.022**	1,276.0 (1,065.6)	1,783.1 (1,385.6)	**.037**
WSP	2,846.8 (1,076.4)	3,801.7 (1,356.5)	**<.001**	2,834.1 (1,152.4)	3880.7 (1,292.0)	**<.001**	2301.3 (696.4)	2,727.8 (853.4)	**.006**	7,895.4 (2,457.4)	10,450.9 (2,736.5)	**<.001**
WUI	3,389.5 (2,538.9)	3,320.5 (1,771.2)	.943	4,421.7 (2,586.01)	4,358.2 (2,979.6)	.797	2,433.7 (1,340.2)	2,636.2 (3,137.0)	.339	10,290.8 (6,522.5)	10,304.4 (7,472.6)	.894
WUS	3,742.6 (1,246.9)	3,712.1 (1,239.0)	.316	5,834.9 (1,166.4)	6,012.2 (1,301.5)	.109	3,210.7 (824.4)	3,500.9 (790.4)	**.003**	12,477.6 (2,820.7)	13,225.2 (3,050.1)	**.009**
Total	4,237.5 (4,022.6)	4,296.7 (3,874.5)	.081	6,353.6 (11,362.8)	5,240.2 (4,678.4)	.123	505.5 (405.0)	690.5 (520.2)	.587	13,780.9 (12,990.2)	13,297.1 (11,660.4)	.544

[a] p-value for wilcoxan signed rank comparing preferred to non-preferred

Preferred vs Non-Preferred Actigraph GT3x-bt Lab Activity Results

Statistically significant differences of mean CPM of the GT3x-bt's were found between the preferred and non-preferred wrists sites over the time participants were performing each lab activity. Counts per minute of the X-axis showed significant differences in COM (p= .005) and WSP (p= <.001). For the Y-axis, differences included BB (p= <.001), COM (p= .005), RB (<.001), WSP (p= <.001), and WUS (p= .010). For the Z-axis, differences included BB (p= <.001), COM (p= .015), RB (p= <.001), Relax (p= .014), WSP (p= <.001), and Total (p= .020). Lastly, for tCPM, differences were found in BB (p= <.001), COM (p= .004), RB (p= <.001), Relax (p= .027), WSP (p= .001), and WUS (p= .043). COM and WSP were the only activities to have significant differences across all axes and tCPM. Means and standard deviations of each activity can be found in Table 4.

Table 4

Summary of Actigraph GT3x-bt Lab Activities Results

	GT3x											
	X-axis			Y-axis			Z-axis			Tcpm		
	Preferred	Non-Preferred	p-value[a]	Preferred	Non-Preferred	p-value[a]	Preferred	Non-Preferred	p-value[a]	Preferred	Non-Preferred	p-value[a]
BB	16,306.9 (18,350.7)	12,362.8 (2,494.5)	.052	17,095.8 (2,555.5)	14,732.7 (3,337.3)	**<.001**	12,070.9 (2,482.3)	9,675.6 (1,996.0)	**<.001**	41,930.0 (5,385.3)	37,255.5 (6,077.3)	**<.001**
COM	457.9 (359.7)	544.7 (311.5)	**.035**	433.2 (356.7)	679.5 (567.8)	**.005**	550.8 (546.1)	682.4 (453.4)	**.015**	1,426.4 (1,233.1)	1,803.5 (1,055.2)	**.004**
RB	7,965.6 (1,151.3)	7,540.4 (2,204.6)	.106	10,983.6 (2,192.9)	7784.8 (2349.6)	**<.001**	9,018.0 (1,580.8)	6,463.9 (1,692.1)	**<.001**	28,038.1 (4,508.6)	22,003.7 (5,935.5)	**<.001**
Relax	582.8 (495.5)	802.0 (607.2)	.055	407.3 (365.0)	650.4 (624.7)	.150	564.0 (498.9)	779.8 (557.0)	**.014**	1,532.8 (1,270.7)	2,143.6 (1,594.0)	**.027**
WSP	3,269.6 (1,100.6)	4,337.9 (1,365.4)	**<.001**	2,886.7 (1,174.0)	4,355.8 (1,347.8)	**<.001**	2,381.2 (734.8)	3,076.2 (1,440.0	**<.001**	8,563.6 (2,570.6)	11,542.7 (2,867.9)	**<.001**
WUI	3,940.4 (2,686.1)	3,814.8 (3,331.5)	.309	4,594.5 (3,072.1)	4,695.1 (3,491.7)	.572	2,609.6 (991.4)	2,606.4 (1,416.3)	.052	11,109.3 (6,414.5)	10,899.0 (7,463.8)	.210
WUS	3,917.9 (1,168.9)	3,996.6 (1,285.5)	.992	5,823.9 (1,185.2)	6,115.7 (1452.0)	**.010**	3,439.5 (1,031.3)	3,497.7 (923.3)	.417	13,080.4 (2,929.7)	13,712.0 (3,210.2)	**.043**
Total	5,205.9 (8,626.3)	4,771.3 (4,251.3)	.756	6,032.2 (5,929.5)	5,573.4 (4967.2)	.771	4,376.3 (4,308.1)	3,826.0 (3,267.5)	**.020**	15,097.2 (14,307.9)	14,194.3 (12,304.4)	.460

[a]p-value for wilcoxan signed rank comparing preferred to non-preferred

Preferred vs Non-Preferred Actigraph Link Free Living Conditon Results

There were no statistical differences between preferred and non-preferred for the X (difference 28.5 CPM for preferred vs non-preferred: 95% CI [-17.4, 74.3], p= .214), Y (35.4, 95%CI [-11.1, 81.8], p= .130), Z (54.2, 95% CI [-1.2, 109.5], p= .055) and tCPM (118.0, 95%CI [-20.7, 256.6, p= .0924) average daily counts from free-living data. Means and standard deviations of the two wrists can be found in Table 5.

Table 5

Summary of Free Living Data Actigraph GT9X Link, mean (SD) average counts per minute

	Preferred	Non-Dominant	p-value
X-axis	963.5(215.8)	935.0(202.7)	.214
Y-axis	979.1 (280.2)	943.8 (278.3)	.130
Z-axis	1072.6 (211.8)	1018.4(218.0)	.055
tCPM	3015.2(665.5)	2897.2(671.2)	.092

Hypothesis Two

Hypothesis Two proposed that mean counts per minute of the X, Y, Z axes and mean tCPM of the Actigraph GT9X Link would not be significantly different from the Actigraph GT3x-bt within the preferred, non-preferred wrists, and the right hip sites over the time participants were performing each lab activity.

Actigraph Link vs GT3x-bt X-Axis

These data also counters Hypothesis Two, as results report significant differences in the X-axis between the two devices on the preferred wrist, non-preferred wrist, and hip locations. Note, axes that were pointing in the same direction for each device were compared. For example, the X-axis of the Link pointed in the same direction of the Y-axis of GT3x-bt and were compared. GT3x-bt recorded significantly higher CPM of the preferred wrist for BB (p= <.001), COM (p= .019), RB (p= <.001), Relax (p= .041), WUI (<.001), WUS (p= <.001), and the total mean CPM across all activities (p= <.001). The GT3x-bt also recorded significantly higher CPM for each activity and total CPM across all activities (p= <.001 and p= .027 for WSP) except for Relax (p= .309). At the hip location, GT3x-bt's CPM were significantly higher for BB (p= .010), RB (p=.004), WSP (p= .013), WUS (p= .010), and Total (p= .006). Means and standard deviations of location can be found in Table 6.

Table 6

Summary of Actigraph Link vs GT3x-bt X-Axis' results

X-axis[b]									
	Preferred			Non-Preferred			Hip		
	Link	GT3x-bt	p-value[a]	Link	GT3x-bt	p-value[a]	Link	GT3x-bt	p-value[a]
BB	11,779.4 (1,895.3)	16,306.9 (18,350.7)	**<.001**	11,325.1 (3,045.3)	12,362.8 (2,494.5)	**.003**	4,288.4 (1,408.8)	4363.1 (1,419.4)	**0.010**
COM	361.2 (352.6)	457.9 (359.7)	**<.001**	443.4 (247.8)	544.7 (311.5)	**<.001**	4.5 (9.5)	2.9 (6.0)	.239
RB	7,344.3 (1,072.5)	7,965.6 (1,151.3)	**<.001**	6,812.2 (1,942.5)	7,540.4 (2,204.6)	**<.001**	3,320.7 (3,145.4)	2,590.2 (779.3)	**.004**
Relax	469.0 (421.0)	582.8 (495.5)	**<.001**	661.9 (546.1)	802.0 (607.2)	**<.001**	17.6 (36.2)	16.2 (34.7)	.413
WSP	2,846.8 (1,076.4)	3,269.6 (1,100.6)	**<.001**	3,801.7 (1,356.5)	4,337.9 (1,365.4)	**.001**	3,018.8 (776.3)	3,120.7 (791.8)	**.013**
WUI	3,389.5 (2,538.9)	3,940.4 (2,686.1)	**<.001**	3,320.5 (1,771.2)	3,814.8 (3,331.5)	.141	3,645.3 (1,664.9)	3,704.8 (1,616.7)	.153
WUS	3,472.6 (1,246.9)	3,917.9 (1,168.9)	**<.001**	3,712.1 (1239.0)	3,996.6 (1,285.5)	**.002**	3,987.0 (1,088.3)	4,080.3 (1088.0)	**.010**
Total	4,237.5 (4,022.6)	5,205.9 (8,626.3)	**<.001**	4,296.7 (3,874.5)	4,771.3 (4,251.3)	**<.001**	2,611.7 (2,268.7)	2,554.0 (1,969.0)	**.006**

[a] p-value for wilcoxan signed rank comparing preferred to non-preferred
[b] x-axis refers to the orientation of the Link device – comparisons are made to the relevant axis for the GT3x-bt

Actigraph Link vs GT3x-bt Y-Axis

Significant differences in the Y-axis at the preferred wrist were also found in activities including BB (p= <.001), COM (p= <.001), RB (p= <.001), Relax (p= <.001), WUI (p= .047), and Total (p= <.001). Significant differences at the non-preferred wrist included BB (p= <.001), COM (p= <.001), RB (p= <.001), Relax (p= <.001), WSP (p= <.001), WUI (p= .003), WUS (p= <.001), and Total (p= <.002). At the hip, there were two significant differences, in WSP (p= .009) and Total (p= .005). Mean and standard deviations for each activity can be found in Table 7.

Table 7

Summary of Actigraph Link vs GT3x-bt Y-Axis' results

Y-Axis[b]									
	Dominant			Non-dominant			Hip		
	Link	GT3x-bt	p-value[a]	Link	GT3x-bt	p-value[a]	Link	GT3x-bt	p-value[a]
BB	20,371.4 (24,607.5)	17,095.8 (2,555.5)	**<.001**	13,900.9 (2,565.8)	14,732.7 (3,337.3)	**<.001**	2442.1 (678.4)	2429.0 (692.2)	0.530
COM	351.7 (334.3)	433.2 (356.7)	**<.001**	470.4 (295.4)	679.5 (567.8)	**<.001**	15.3 (21.2)	13.9 (22.1)	0.171
RB	10,344.2 (1,941.3)	10,983.6 (2,193.0)	**<.001**	7,609.2 (2,157.8)	7,784.8 (2,349.6)	**<.001**	15.3 (21.2)	13.9 (22.7)	**.0453**
Relax	317.4 (264.0)	407.3 (365.0)	**<.001**	449.8 (409.4)	650.4 (624.7)	**<.001**	18.2 (32.9)	18.3 (36.8)	0.173
WSP	2,834.1 (1,152.4)	2,886.7 (1,174.0)	.159	3,880.7 (1,292.0)	4,355.8 (1,347.8)	**<.001**	1,856.1 (491.4)	1,557.1 (585.1)	**0.009**
WUI	4,421.7 (2,586.0)	4,594.5 (3,072.1)	**.047**	4,358.2 (2,979.6)	4,695.2 (3,491.7)	**.003**	1,955.4 (850.2)	1,873.8 (720.5)	0.245
WUS	5,834.9 (1,166.4)	5,823.9 (1,185.2)	.537	6,012.2 (1,301.5)	6,115.7 (1,452.0)	**<.001**	2,079.2 (427.8)	1,990.3 (600.8)	0.382
Total	6,353.6 (11,362.8)	6,032.2 (5,929.5)	**<.001**	5,240.2 (4,678.4)	5,573.4 (5,573.4)	**<.001**	1629.1 (1,203.9)	1573.4 (1,217.9)	**0.005**

[a] p-value for Wilcoxan signed rank comparing preferred to non-preferred

[b] y-axis refers to the orientation of the Link device – comparisons are made to the relevant axis for the GT3x-bt's (X-axis)

Actigraph Link vs GT3x-bt Z-Axis

Significant differences resulted in the Z-axis at the preferred wrist for the following activities: BB (p= <.001), RB (p= <.001), Relax (p= .006), WUI (p= .009), and Total (p= <.001). Significant differences at the non-preferred wrist were found for COM (p= .008), RB (p= .022), Relax (p= .004), WSP (p= .021), WUS (0.069), and Total (p= <.001). At the hip, there were significant differences for BB (p= .035) and Total (p= .017). Mean and standard deviations for each activity can be found in Table 8.

Table 8

Actigraph Link vs GT3x-bt Z-Axis' results

Z-axis									
	Preferred			Non-Preferred			Hip		
	Link	GT3x-bt	p-value[a]	Link	GT3x	p-value[a]	Link	GT3x-bt	p-value[a]
BB	10,324.6 (1,638.0)	12,070.9 (2,482.3)	**<.001**	9,462.8 (1,969.7)	9,675.6 (1,996.0)	.111	2,870.3 (802.6)	2635.2 (743.7)	**0.035**
COM	488.6 (422.1)	550.8 (546.1)	.106	608.4 (386.5)	682.4 (453.4)	**.008**	25.5 (34.8)	23.2 (27.4)	0.711
RB	8,217.3 (1,343.2)	9,018.0 (1,580.8)	**<.001**	6,261.8 (1,583.1)	6,463.9 (1,692.1)	**.022**	3,400.5 (645.3)	3,331.7 (705.8)	0.453
Relax	505.5 (405.0)	564.0 (498.9)	**.006**	690.5 (520.2)	779.8 (557.0)	**.004**	28.8 (56.1)	15.9 (32.2)	0.111
WSP	2,301.3 (696.4)	2,381.2 (734.8)	.061	2,725.8 (853.4)	3,076.2 (1440.0)	**.021**	1,555.3 (950.5)	1,378.5 (693.8)	0.734
WUI	2,433.7 (1,340.2)	2,609.6 (991.4)	**.009**	2,636.2 (3,137.0)	2606.4 (1,416.3)	0.069	1,830.2 (870.9)	1,541.2 (721.0)	0.299
WUS	3,210.7 (824.4)	3,439.3 (1,031.3)	.050	3500.9 (790.4)	3497.7 (923.2)	0.918	2,242.8 (778.6)	2,063.5 (609.6)	0.116
Total	3,296.0 (3,707.9)	4,376.3 (4,308.1)	**<.001**	3,698.3 (3,344.0)	3,826.0 (3,267.5)	**<.001**	1,707.6 (1,387.5)	1569.9 (1,294.4)	**0.017**

[a] p-value for wilcoxan signed rank comparing preferred to non-preferred

Actigraph Link vs GT3x-bt mean tCPM

Significant differences were found for the mean tCPM at the preferred and non-preferred wrist for every activity and Total (p= <.001). At the hip, significant differences included BB (p= .009), WSP (p= .005), WUI (p= .004), and Total (p= <.001). Mean and standard deviations for each activity can be found in Table 9.

Table 9

Actigraph Link vs GT3x-bt tCPM results

	Dominant			Non-dominant			Hip		
	Link	GT3x-bt	p-value[a]	Link	GT3x-bt	p-value[a]	Link	GT3x-bt	p-value[a]
BB	3,7624 (5,194.6)	4,1930.0 (5,385.3)	**<.001**	35,078.7 (5,420.0)	37,255.5 (6,077.3)	**<.001**	9,600.7 (2,481.3)	9,427.3 (2,427.5)	**.009**
COM	1,183.4 (1,077.2)	1,426.4 (1,233.1)	**<.001**	1,522.0 (884.7)	1,803.5 (1,055.2)	**<.001**	45.3 (57.9)	40.0 (46.4)	.837
RB	25,719.0 (4,318.3)	28,038.0 (4,508.5)	**<.001**	20,715.8 (5,405.3)	22,003.7 (5,935.5)	**<.001**	9,156.9 (1,755.1)	9,053.6 (1,864.7)	.106
Relax	1,276.0 (1,065.6)	1,532.8 (1,270.7)	**<.001**	10,450.9 (2,736.5)	11,542.7 (2,867.9)	**<.001**	64.6 (118.6)	50.4 (93.9)	.365
WSP	7,895.4 (2,457.5)	8,563.6 (2,570.6)	**<.001**	10,450.9 (2,736.5)	11,542.7 (2,867.9)	**<.001**	6,430.2 (1,351.2)	6,044.3 (1,057.4)	**.005**
WUI	10,290.8 (6,522.5)	11,109.3 (6,414.5)	**<.001**	10,304.4 (7,472.6)	10,899.0 (7,463.8)	**<.001**	7,430.9 (2,301.8)	7,119.9 (2,246.4)	**.004**
WUS	12,477.6 (2,820.7)	13,080.4 (2,929.7)	**<.001**	13,225.2 (3,050.1)	13,712.0 (3,210.2)	**<.001**	8,308.9 (1,525.5)	8,134.0 (1,725.7)	.185
Total	13,780.9 (12,990.2)	15,097.2 (14,307.9)	**<.001**	13,297.1 (11,660.4)	14,194.3 (12,304.4)	**<.001**	5,862.5 (4,135.2)	5,695.6 (4,063.9)	**<.001**

[a] p-value for wilcoxan signed rank comparing preferred to non-preferred

Hypothesis Three

Spearman's Rho between preferred and non-preferred were not associated with BMI, age, average free-living CPM, self-reported vigorous physical activity or total METS from IPAQ, or between those classified as overweight (BMI≥25 lbs/in^2) and normal weight (BMI<25 lbs/in^2) or between left and right preferred handedness. The Actigraph Link's preferred and non-preferred in relation to the hip tCMP average spearman's Rho was 0.850 and 0.838 respectively in the free-living condition. Table 10 reports the mean, standard deviation, minimum, maximum, and range of correlation in the free living condition. Table 11 reports the mean, standard deviation, minimum, maximum, and range of the correlation found between the preferred wrist and hip as well as the non-preferred wrist and hip.

Table 10

Summary of Spearman's Rho for Preferred vs Non-preferred in free-living condition

Spearman's Rho	Mean(sd) Correlation	Minimum Correlation	Maximum Correlation	Range
X-axis	0.910 (.081)	0.714	1.000	0.286
Y-axis	0.919(.085)	0.691	1.000	0.310
Z-axis	0.930(.075)	0.691	1.000	0.310
tCPM	0.932(.075)	0.691	1.000	0.310

Table 11

Summary of Spearman's Rho for each Wrist vs Hip

Spearman's Rho (tCPM)	Mean(SD) Correlation	Minimum Correlation	Maximum Correlation	Range
Preferred vs Hip	0.850 (.150)	0.429	1.000	0.571
Non-Preferred vs Hip	0.838 (.149)	0.429	1.000	0.571

Discussion

The results from the current study demonstrate that during certain activities there were significant differences in counts measured on the preferred and non-preferred wrists. Examination of each individual axis demonstrates the movements during specific to each prescribed activity. The tCPM measure depicts a summary of a subject's measured physical activity. The results demonstrate within the Actigraph Link that the activities of BB, COM, RB, Relax, WSP, and WUS were significantly differently between the two wrists. It is interesting to note with each of these activities the preferred and non-preferred wrists typically were not performing the same actions as confirmed by detailed observation field notes. Handedness demonstrates the tendency to favor one hand for performance of skilled manual tasks and occurs in an estimated 96% of the population (Annett, 1998). For example, when shooting a basketball the preferred wrist typically was used to shoot the basketball as the non-preferred wrist held the ball still on the shooting hand. During the computer use condition, the preferred wrist normally operated the mouse. The preferred wrist usually was used to hold and swing the racquet. While relaxing and while walking the preferred wrist normally held the smartphone while the non-preferred move more freely. When the phone was being used the preferred wrist was typically more static than the non-preferred wrist. Finally, walking up stairs typically the right wrist (preferred or non-preferred) was used to hold the rails going up and no rails were used coming down. Contrarily, walking up an incline showed to be reciprocal actions for the two wrists for as one moved forward the other moved back. However, when looking at the free-living data there were no significant difference across all measures between the preferred and non-preferred wrists. This indicates that even though certain activities displayed differences between preferred and non-preferred wrist that over the week of free living wear, the averaged counts from each wrists were similar.

It was hypothesized that the Actigraph GT3x-bt and Actigraph Link would measure similarly as proposed in hypothesis Two. This was not supported as significant differences between the two devices at each location were found as the GT3x-bt measured significantly higher across the activities at both the preferred and non-preferred wrists for tCPM with approximately a 9% increase in tCPM in the GT3x-bt. It is interesting to note though the devices were more comparable on the hip. The mean difference on the hip is only 15.9 CPM for relaxing and 4.4 CPM for computer (the least amount of movement) and 162 counts per minute across all activities with the Link being higher for both. However, the total differences on the hip were quite small, approximately 2.5%. This fits within the allowable and expected inter-device measurement error 5% (Tryon, 2005; Metcalf, Curnrow, Evans, Voss, & Wilkin, 2002). A possible explanation is the two models record different accelerations. Alternatively, reasoning of these findings include not varying the order of the devices on the wrist. For example, the Actigraph GT3x-bt was closer to the wrist joint which could potentially allow for measuring more hand movement. The Link was more proximal on the wrist where the Link was static and did move as much. This proximal distance on the forearm may have resulted in less linear acceleration compared to the distal GT3x-bt. Following data collection, a single participant completed the study with the Link being more proximal to the wrist joint and the Link CPM per activity was consistently higher than the GT3x-bt on the same wrist. More research is need to determine if small adjustments in placement on the wrist result in meaningful differences in measured movement. Currently, no standardization of wrist placement for free living wear exist.

Next, factors such as age, height, weight, BMI, and IPAQ classifications did not affect the correlation between the preferred and non-preferred wrists. This finding signifies that regardless of these variables the correlations were not different and do not appear to largely influence measuring PA in college students when deciding to use the preferred or non-preferred wrist. As expected the hip with both wrists were positively correlated when measuring PA and both intra-device wrist and hip correlations were similar between the preferred and non-preferred wrists which is consistent with previous research (Hildebrand et al., 2014).

Few studies have examined if there is a difference in measuring physical activity between a person's preferred and non-preferred wrists in college students. The current study's findings were inconsistent with two other studies that found no significant differences between the left and right wrist (Zhang, Rowlands, Murray, & Hurst, 2012; De Man et al., 2016). The current study used a sample of college students and chose tasks that represent daily tasks college students might perform while the previous studies sample did not use college students and did not have tasks representative of college student's daily life nor did it have a free-living condition. Also, a previous study used a commercially available accelerometer which has shown to have inconsistent validity (Evenson, et al. 2015), and only had walking as an activity where no statistical difference was found between the left or right wrist (De Man et al., 2016). The current study was consistent in finding that walking up an incline did not result in significant differences between preferred and non-preferred wrists. However, college students do more than just walking which is why the current study incorporated more tasks to represent this and had a sample size greater than six. Lastly, one previous study that had a 24-hour free-living condition found that the left or right wrist did not have a significant difference in measuring physical activity (Dieu et al., 2015). Though the current study also did not find significant differences between the preferred and non-preferred wrist, it is important to recognize that our study had a longer free-living time period and structured activities that participants completed. In actuality, free-living data may not tell the whole story though when measuring PA since some structured activities did show significant difference between the preferred and non-preferred wrist.

Limitations

One limitation to the study was not varying the position of the Acitgraphs on the wrist. Varying the place of the two devices on each wrist would have shown if wrist placement makes difference as far as measuring physical activity. Future studies should look more in depth into wrist placement closer to the actual wrist joint for higher measured physical activity. Pilot data with one participant who did wear the Link proximal to the wrist joint and the GT3x more distal did show that the tCPM of the Link were higher during all laboratory activities. Also sleep and awake time have not been separated yet in the free-living data. However, total wear time was consistent for all participants. Future studies need to look more in depth at if physical activity is measured differently on the preferred and non-preferred wrist during sleep can potentially take up a large portion of the day and could affect the tCPM for the day as one study found differing activity levels between the dominant and nondominant hands (Sadeh, Sharkey, & Carskadon, 1994). Another study has found that the sleep function of ActiGraph Link performs comparable to a validated accelerometer and can measure both sleep and PA conjointly (Lee & Suen, 2017).

Conclusion

Researchers should be aware when measuring physical activity in structured activities that placing the accelerometer on the preferred and non-preferred wrist can affect the results. Though for free living conditions, less concern should be placed on the preferred or non-preferred wrist. The Actigraph Link and Actigraph GT3X did measure significantly differently on some activities but the total differences on the hip were within the expected measurement error. Also factors of BMI, IPAQ scored, height, weight, age did were not cofounding variables when looking at the correlations between the preferred and non-preferred wrist. Lastly, wrist placement for an accelerometer does show to have a good correlation to hip placement when measuring physical activity. In conclusion, this study's implications are to assist with learning more about measuring PA with accelerometry to help properly identify needs and develop interventions in the general population to improve overall health.

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Appendix

A. Institutional Review Board Committee Approval

To:	Bryce Timothy Daniels BELL 4188
From:	Douglas James Adams, Chair IRB Committee
Date:	03/01/2018
Action:	**Expedited Approval**
Action Date:	03/01/2018
Protocol #:	1802100792
Study Title:	The Comparison of the Preferred and Other Wrist When Measuring Physical Activity in College Students
Expiration Date:	02/28/2019
Last Approval Date:	

The above-referenced protocol has been approved following expedited review by the IRB Committee that oversees research with human subjects.

If the research involves collaboration with another institution then the research cannot commence until the Committee receives written notification of approval from the collaborating institution's IRB.

It is the Principal Investigator's responsibility to obtain review and continued approval before the expiration date.

Protocols are approved for a maximum period of one year. You may not continue any research activity beyond the expiration date without Committee approval. Please submit continuation requests early enough to allow sufficient time for review. Failure to receive approval for continuation before the expiration date will result in the automatic suspension of the approval of this protocol. Information collected following suspension is unapproved research and cannot be reported or published as research data. If you do not wish continued approval, please notify the Committee of the study closure.

Adverse Events: Any serious or unexpected adverse event must be reported to the IRB Committee within 48 hours. All other adverse events should be reported within 10 working days.

Amendments: If you wish to change any aspect of this study, such as the procedures, the consent forms, study personnel, or number of participants, please submit an amendment to the IRB. All changes must be approved by the IRB Committee before they can be initiated.

You must maintain a research file for at least 3 years after completion of the study. This file should include all correspondence with the IRB Committee, original signed consent forms, and study data.

B. Consent Form

Preferred vs Other Wrist Measured Physical Activity Study

Consent to Participate in a Research Study

Principal Researcher: Bryce T. Daniels

IRB Protocol #: 1802100792

This is a permission form for research participation. It contains important information about this study and what to expect if you choose to participate.

Your participation is voluntary.

Please consider the information carefully. Feel free to discuss the study with your friends and family and to ask questions before making your decision whether or not to participate. If you permit to participate, you will be asked to sign this form and will receive a copy of the form.

INVITATION TO PARTICIPATE

You're being invited to participate in a research study about measured physical activity.

WHAT YOU SHOULD KNOW ABOUT THE RESEARCH STUDY

Who is the Principal Researcher?

Bryce T. Daniels

University of Arkansas, Fayetteville, AR 72701

Phone: (501) 358-8110, Email: bxd013@uark.edu

What is the purpose of this research study?

To understand the differences in measured physical activity on a preferred wrist compared to the other wrist.

Who will participate in this study?

University of Arkansas students aged 18-25 whom have no current injuries, limitations with limbs, or movement limitations, and own a smart phone.

What will you be asked to do?

Your participation will require the following:

- Having their height and weight measured
- Completing a questionnaire about your physical activity habits
- Completing daily college activities (as you normally would) which includes: walking with a smart phone, walking up and down stairs, walking up an incline, relaxing, shooting a basketball, hitting a racquetball, and study/homework time
- Wear activity monitors during the tasks
- Wearing activity monitors for 7 days after the lab visit living life as you normally would
- Completing a non-wear time log
- Returning to the lab to return the activity monitors

What are the possible risks or discomforts?

Participation will require time taken up for your visit to the University of Arkansas Exercise Science Research Center and the 7 days to collect your free-living data. We do not expect that there will be any risks, discomforts or inconveniences associated with taking part in this study beyond those of performing daily living activities.

What are the possible benefits to participating in this study?

Upon request you may receive a copy of your results.

How long will the study last?

You will visit the Exercise Science Research Center at the University of Arkansas. The visit should not take more than 2 hours. You will be asked to wear the activity monitors for 24 hours a day and record any non-wear times for 7 days. Then you will return to the lab to return the non-wear time log and activity monitors.

Will you child have to pay for anything?

No, there will be no cost associated with your participation.

What are the options if I do not want to be in the study?

If you do not want to be in this study, you may refuse to participate. If you decide to participate and then change your mind, you may quit participating at any time. You will not be punished or discriminated against in any way if you refuse to participate. You will not be affected in any way if you refuse to participate.

How will my confidentiality be protected?

All information will be kept confidential to the extent allowed by applicable State and Federal law and University policy. Only the Investigators and research assistants will have access to your contact information. All the data will be recorded using an identification number. All data, including contact information and codes, will be stored in a locked room.

Will I know the results of the study?

At the conclusion of the study you will have the right to request feedback about the results. You may contact the Principal Researcher, Bryce Daniels. You will receive a copy of this form for your files.

What do I do if I have questions about the research study?

You have the right to contact the Principal Researcher as listed below for any concerns that you may have. Bryce Daniels, Phone: (501) 358-8110, Email: bxd013@uark.edu

You may also contact the University of Arkansas Research Compliance office listed below if you have questions about your rights as a participant, or to discuss any concerns about, or problems with the research.

Ro Windwalker, CIP, Institutional Review Board Coordinator, Research Compliance

University of Arkansas, 109 MLKG Building, Fayetteville, AR 72701-1201

479-575-2208, irb@uark.edu

I have read the above statement and have been able to ask questions and express concerns, which have been satisfactorily responded to by the investigator. I understand the purpose of the study as well as the potential benefits and risks that are involved. I understand that participation is voluntary. I understand that significant new findings developed during this research will be shared with me. I understand that no rights have been waived by signing the consent form. I have been given a copy of the consent form.

Participant's Name (print): ____

Signature:_____________________________________ Date: _______________________

C. Non-Wear Time and Sleep Log

Activity Monitors

As part of the research study 'The Comparison of the Preferred and Other Wrist When Measuring Physical Activity in College Students' (IRB Protocol #: 1802100792) you been given two activity monitors to wear for the next 7 days (including while you sleep). The activity monitor measures the amount of movement similar to a pedometer. It does not record location (ie like a GPS) or any other type of personal information.

- The activity monitors fits on your wrist. The activity monitors should sit on the bony parts of each wrists
- Please **take it off for water activities** including bathing, showering, and swimming. Prolonged submersion in water may cause damage to the device.
- We ask for you to wear the activity monitors **continuously for the next 7 days**. We want to encourage you to wear them while sleeping as well.
- If you remove the monitor, please record the time they took it off and the time they put it back on and what activity they were doing in the attached diary.
- **You should not take the activity monitor out of the plastic clip.** It is secured with tape.
- The monitors have a battery inside so do not put the activity monitor in fire or flame as it may explode.
- Don't use alcohol to clean the activity monitor.
- Also remember to be consistent on wearing the left watch on the left wrist and the right watch on the right wrist throughout the 7 days

Please return both the accelerometers and completed diary to the Exercise Science Research Center __________________________ .

If you have any questions please contact:

Bryce Daniels **–** (501) 358-8110 or bxd013@uark.edu

Remember to wear during sleep! Thank you for your help and support!

Day Non-Wear Time Log

Day	
1	Shower: Lights Out Time: Wake Time: Other:
2	Shower: Lights Out Time: Wake Time: Other:
3	Shower: Lights Out Time: Wake Time: Other:
4	Shower: Lights Out Time: Wake Time: Other:
5	Shower: Lights Out Time: Wake Time: Other:
6	Shower: Lights Out Time: Wake Time: Other:
7	Shower: Lights Out Time: Wake Time: Other:

D. Data Collection Sheet

Subject ID: ________   Birthdate: _____/_____/______

Gender: M   F   Age: ________   Height: ________   Weight: _____   BMI: _____

Preferred Arm: L   R

Task	Observations	
	Start Time:	End Time:
	Start Time:	End Time:
	Start Time:	End Time:
	Start Time:	End Time:
	Start Time:	End Time:
	Start Time:	End Time:
	Start Time:	End Time: