GET SQORD! COMPARING TWO PHYSICAL ACTIVITY MEASUREMENT DEVICES

By

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Abstract

In this project, we compared the physical activity (PA) data gathered by the Actigraph GT3X triaxial accelerometer, a widely used and validated device, with that of the novel SQORD device (http://www.sqord.com). The purpose of this study was to compare PA data collected from SQORD and the Actigraph to determine whether SQORD was a reliable alternative to the Actigraph. Nineteen men and women, ages 18-25, were recruited from University of Arizona to take part in a 4-day study. Each participant was asked to 1: wear both the Actigraph and SQORD for 4 consecutive days, 2: keep a log of their moderate-to-vigorous exercise, and 3: allow their height and weight to be measured. Intensity values and activity points were analyzed using the standard cut-off points as determined by Troiano (2010) cut-off points. Average daily moderate PA was 2 hours and 48 minutes and average daily vigorous PA was 48 minutes (Actigraph). Exact number of hours in moderate and vigorous PA were undeterminable for SQORD. Compared to the gold standard Actigraph, the SQORD watch was deemed an unreliable alternative to the Actigraph GT3X in providing users with PA feedback and measuring PA.

ABSTRACT

In this project, we compared the physical activity data gathered by the Actigraph GT3X triaxial accelerometer, a widely used and validated device, with data collected from a second accelerometer, the SQORD device (http://www.SQORD.com). The Actigraph GT3X triaxial accelerometer measures physical activity according to one's acceleration and scales the information based on intensity level. "The GT3X appears to overall be an accurate tool for EE [Energy Expenditure] prediction, which proved sufficiently sensitive to discriminate between different intensities of PA [Physical Activity], at least for activities performed in a laboratory setting" (Santos-Lozano, *Actigraph GT3X: Validation and Determination of Physical Activity Intensity Cut Points*, 7). In contrast, the SQORD accelerometer is a new device designed to encourage users to increase their physical activity through web-based feedback about their PA. SQORD is wireless, allowing the wearer to monitor his PA throughout the day using a web-based interface. The user receives "points" for their daily PA based on the intensity and duration of each PA bout.

The purpose of this study was to compare PA data collected using SQORD with data gathered by the Actigraph to determine whether SQORD is a reliable alternative to the Actigraph. Nineteen men and women, ages 18-25, were recruited from University of Arizona undergraduate and graduate classes, clubs, and on-campus organizations to take part in a 4-day study. Each participant was asked to 1: wear both the Actigraph and SQORD for 4 consecutive days, 2: keep a log of their moderate-to-vigorous exercise, and 3: allow their height and weight to be measured. Intensity values and activity points were analyzed using the standard cut-off points as determined by Troiano (2010) cut-off points. Of the nineteen adults that completed all study activities, average daily moderate PA was 2 hours and 48 minutes and average daily

vigorous PA was 48 minutes (Actigraph). Exact number of hours in moderate and vigorous PA were undeterminable for SQORD based on the information provided by SQORD. Compared to the gold standard Actigraph, the SQORD watch was deemed an unreliable alternative to the Actigraph GT3X.

INTRODUCTION

Overview of Physical Activity and Physical Activity Measurement Devices

Physical activity is defined as "all bodily actions produced by the contraction of skeletal muscle that increase energy expenditure above basal level" (Butte, *Assessing Physical Activity Using Wearable Monitors: Measures of Physical Activity*, 1). Now, more than ever, monitoring physical activity (PA) is of interest to both non-researchers and researchers alike. The U.S. Department of Health and Human Services (HHS) establish a set of healthy PA guidelines for Americans. The goal of these guidelines is to validate that "regular physical activity over months and years can produce long-term health benefits [and that] realizing these benefits requires physical activity each week" (HHS). With the steady increase in the prevalence of obesity, diabetes, and cardiovascular disease in the United States, many people see PA promotion and the maintenance of standardized PA guidelines as a solution to this growing epidemic.

The US Department of HHS discovered the following as a result of regular human PA. Regular PA leads to a reduction in adverse health outcomes such as obesity, cardiovascular disease, heart attack, diabetes, and other chronic diseases. Moreover, aerobic (endurance) and muscle-strengthening (resistance) exercise produce positive health results such as reduction in the risk for chronic illnesses, reduction in blood pressure, psychological well-being, and healthy muscles, bones, and joints. As one increases his or her frequency, intensity, and duration of PA,

so too do the additional health benefits of regular PA increase. Any PA is better for one's health than no PA at all, and the health benefits of regular PA are indiscriminate; i.e., they are experienced by all children and adolescents, adults, and racial and ethnic groups. Ultimately, PA health benefits outweigh adverse PA outcomes (HHS).

To maximize these potential effects, the US Department of HHS outlines the following PA parameters for American adults and children. Children and adolescents should engage in at least 60 minutes of PA every day. Aerobic exercise should compromise most of the 60 minutes and should be moderate-to-vigorous physical activity (see Table 1 below). In addition, muscle-strengthening exercise should be included 3 days per week, and bone-strengthening exercise should be included 3 days per week. Encouraging young people to engage in PA that is age-appropriate, fun, and diverse is key to ensuring regular PA among children.

Adults should refrain from prolonged periods of inactivity and engage in 150 minutes of moderate or 75 minutes of vigorous (see Table 1 below) PA weekly. Furthermore, adults should participate in muscle-strengthening exercises two days per week, and for substantial health benefits, adults should practice 300 minutes of moderate or 150 minutes of vigorous aerobic PA weekly (HHS).

The following table (Table 1) contains the definitions of PA types and intensity levels as defined by the Centers for Disease Control and Prevention (CDC).

Types and Intensity Levels of Physical Activity	
Aerobic Physical Activity	Type of PA in which the body's muscles move rhythmically for a continue bout of time. Aerobic PA includes cardiorespiratory fitness (CDC)
Muscle-strengthening Physical Activity	Physical activity, including exercise that increases skeletal muscle strength, power, endurance, and mass (CDC)
Moderate Physical Activity	On an absolute scale, physical activity that is done at 3.0 to 5.9 times the intensity of rest. On a scale relative to an individual's personal capacity, moderate-intensity physical activity is usually a 5 or 6 on a scale of 0 to 10 (CDC)
Vigorous Physical Activity	On an absolute scale, physical activity that is done at 6.0 or more times the intensity of rest. On a scale relative to an individual's personal capacity, vigorous-intensity physical activity is usually a 7 or 8 on a scale of 0 to 10 (CDC)

Table 1. Types and intensity levels of physical activity

In effect, changing patterns in PA leads to changes in body composition and physiology. The physiological changes, in turn, contribute to a person's susceptibility to becoming obese and developing chronic illnesses such as diabetes and cardiovascular disease. By monitoring PA, we are indirectly monitoring our physiology, and also indirectly monitoring our risk for developing chronic diseases. The link between inadequate PA and incident chronic diseases such as obesity, diabetes, and cardiovascular disease has been well-studied.

PA promotion may increase awareness of lifestyle habits and encourage behavioral changes that positively impact overall health. This may be accomplished in several ways. PA measurement, through self-monitoring, can increase awareness of PA, leading to increased PA. Second, knowing how much PA one typically engages in allows one to set goals to increase PA. Third, PA measurement is a form of feedback that provides information about one's activity,

thus potentially motivating that person to engage in PA. An important aspect of PA promotion, PA measurement, is the central focus of this study because it allows PA tracking with a device to quantify the frequency, intensity, type, and time of PA. This information can be related to health-related PA goals, such as time spent in "moderate-to-vigorous-physical activity" (MVPA). In addition, self-monitoring may itself be a motivational device, increasing PA because increased awareness is occurring (just as writing down what one eats frequently often leads to changes in the way one eats).

PA measurement is a well-studied research topic and many PA measurement methods have been developed, both commercially and for use in research. In contrast to techniques such as indirect calorimetry, wearable PA measurement devices present a more convenient, accessible, and affordable method of estimating energy expenditure in free-living individuals. There are a multitude of wearable device options for PA assessment including pedometers, accelerometers, heart rate monitors, multiple sensor systems, and combinations of these. With such an array of devices available, it is important to know how accurately these devices capture PA, so that the most appropriate device may be selected. The purpose of this project was to compare two wearable accelerometer devices – one novel (SQORD) and one widely used (Actigraph GT3X) - and analyze and compare the physical activity data collected by each in order to determine whether the SQORD device is a suitable alternative for the Actigraph accelerometer (an established gold standard field measurement).

PA Measurement and Children's Health

Monitoring PA and finding a suitable PA measurement device that can be used by all people may have important implications for addressing public health concerns related to inadequate PA and risk of chronic disease. Indeed, childhood obesity is a crucial issue that

receives a lot of attention from researchers across many disciplines, including public health, nutrition, and physiological sciences. Designing a fun and innovate way to communicate the importance of PA to children may be helpful in reversing the childhood obesity epidemic in the United States. The SQORD device, designed to encourage children to be more physically active, combines technology with physical activity promotion as an interactive and engaging way to help children become (and stay) more active. The modern trend of combining exercise and technology has been commercially successful, resulting in systems such as the Xbox Kinect and Nintendo Wii. Such systems encourage competition, goal-setting, and PA. The SQORD device also has some of these characteristics, providing virtual awards for children who achiever a specific activity points goal, and enabling competition between friends and classmates, while also being portable (traveling with the youth where s/he goes) and affordable ($15 per device compared to several hundred dollars for gaming systems). If SQORD can provide an accurate assessment of daily PA in addition to "motivational" support, this device could be a viable strategy for researchers to use in intervention programs to motivate children to increase their awareness of their PA, thereby prompting lifestyle and behavioral changes.

METHODS

Research Process

Four men and fifteen women, for a total of nineteen participants, ages 18-25 (average age of 21) were recruited from The University of Arizona to take part in a 4-day study. All subjects met "in good health" standards for engaging in physical activity, as determined by the Physical Activity Readiness Questionnaire (PAR-Q). The University of Arizona Institutional Review Board approved this study.

Recruitment of Participants and Eligibility Criteria Procedures

Recruitment of participants for this study consisted of word-of-mouth, and email. The recruitment email was sent out to individuals interested in the study and was IRB approved. Respondents (interested men and women who met the eligibility criteria) completed the PAR-Q to screen whether they were eligible to participate in structured physical activity and that they met all inclusion criteria (18-30 years of age, University of Arizona student or employee, without physical limitations or medical conditions contraindicating exercise). The PAR-Q identified participants who might have had medical contraindications to engage in a physical activity program without prior medical consent.

Study Procedures

During the 4-day study, each participant completed the following tasks. Written, informed consent was obtained from all eligible respondents, upon which they were enrolled in the study and assigned a study identification number (ID). Anthropometric measurements, including height and weight (in cm and kg respectively) were recorded for each participant. Height was measured in duplicate using a stadiometer and weight was measured in duplicate using a SECA scale; averages of each measure were taken. These data were entered into the ActiLife software to sync the GT3X Actigraph accelerometers. The SQORD device was wirelessly synced using the sync station provided by SQORD; participants were assigned a SQORD username by the Study Data Manager that corresponded to their project ID number.

Participants underwent a brief, 5-minute training on how to wear each of the two accelerometers. Proper placement was demonstrated (as shown in Figure 1 below) – the

Actigraph is worn on the right hip just above the iliac crest, and the SQORD device is worn on the right or left wrist.

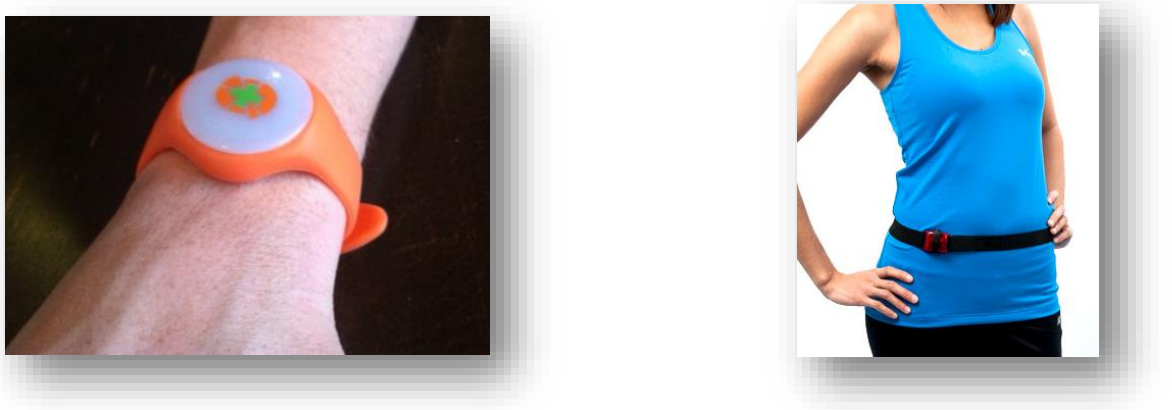

Figure 1. SQORD placement on the left or right wrist and Actigraph placement above the waist.

Participants were instructed to keep a daily physical activity log where they recorded all moderate-to-vigorous PA. In this log, participants were also instructed to indicate whether or not wearing the accelerometers encouraged them to exercise on any given day. After wearing both devices for two days from the initial sync date and time, participants returned to wirelessly sync the SQORD device using the sync station provided by SQORD. Two days later, participants returned both accelerometers and their completed activity logs.

Data Analysis Procedures

The SQORD data was retrieved from the web-based interface, www.SQORD.com. Physical activity points were obtained from the SQORD graphs of each participant by hovering over each bar and recording the point values in Microsoft Excel. Values were arranged daily and hourly, as seen in Table 1. A snapshot of each graph was also downloaded for qualitative reference.

Using ActiLife software, the Actigraph data was graphed according to the Troiano (2010) cut-off points. Snapshots of each graph were downloaded since Actigraph "counts" were recorded every second. Data was more conveniently and more manageably displayed as 60 second epoch graphs. In comparing SQORD activity points with Actigraph counts, for every bout of moderate physical activity in a one hour period, an asterisk was placed in the corresponding one hour period in Table 2 (See Appendix). For every bout of vigorous physical activity in a one hour period, two asterisks were placed in the corresponding one hour period in Table 2.

Trends in moderate and vigorous counts for Actigraph and SQORD activity points were analyzed. The following calculations were recorded: total number of hours and percentage of time spent in PA over the four days, total number of hours and percentage of time spent in moderate-intensity PA over the four days, total number of hours and percentage of time spent in vigorous-intensity PA over the four days, and mean number of hours spent in PA per day, mean number of hours and percentage of time in moderate-intensity PA per day, and mean number of hours and percentage of time in vigorous-intensity per day (see Table 3).

SQORD analysis consisted of calculating total number of daily activity points and total number of activity points over the four days. Using SQORD cut-off points provided by Coleman Greene (see below), founder of SQORD, the following were determined: percentage of time spent in vigorous-intensity PA per week, percentage of time spent in sedentary/inactive PA per day, percentage of time spent in moderate-intensity (Healthy Category) PA per day, and percentage of time spent in vigorous-intensity (Active-Very Active Category) PA per day. Results are summarized in Table 4.

RESULTS

Accelerometers as PA Measurement Devices

This study spanned three weeks with 7 participants the first week, 9 participants the second week, and 3 participants the third week. Each subject's height and weight were measured. The average height and weight for males were 178.5 cm and 75.1 kg, respectively. The average height and weight for females were 170.1 cm and 67.1 kg, respectively.

Total # Hours with PA for 4 days (any activity on or above sedentary line)	50.9
# Hours with Moderate PA (any activity on or above moderate line)	11.6
# Hours with Vigorous PA (any activity on or above vigorous line)	2.9
# Hours with Sedentary or Light PA (any activity below moderate line)	36.7
Mean # Hours of Activity/Day	12.7
% Time with Moderate PA/Day	21.8%
% Time with Vigorous PA/Day	6.2%
% Time with Sedentary or Light PA	72%

Table 3. Mean calculated Actigraph data for all 19 participants. For PA intensity references, see Figures 2-1 through 2-5.

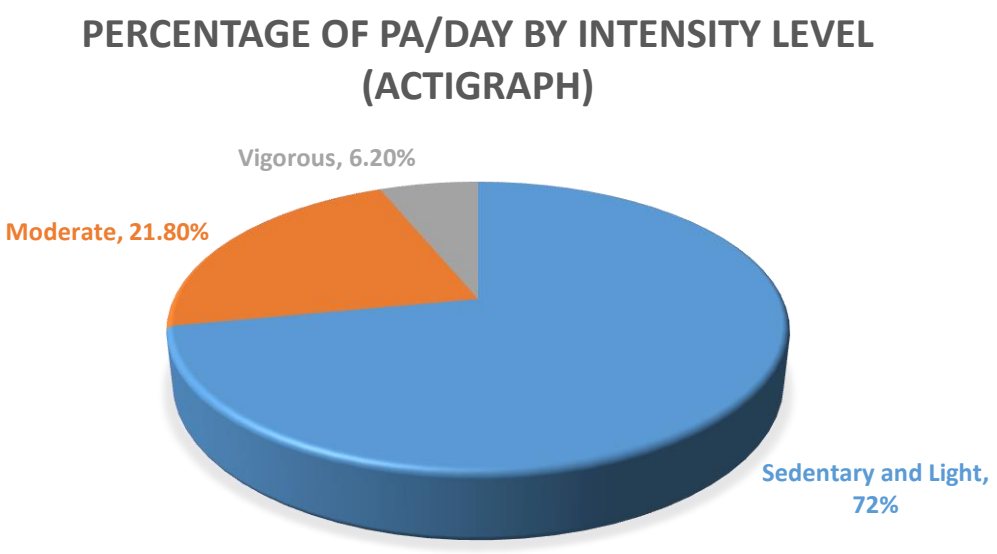

Figure 5. Percentage of PA per day by varying intensity level according to Actigraph.

% Time with Vigorous PA/Day	0-1%
% Time with Moderate PA/Day	49%
% Time with Sedentary or Light PA/Day	50%
Daily Sedentary/Inactive	36.1%
Daily Moderate (Healthy)	28.7%
Daily Vigorous (Active-Very Active)	35.2%

Table 4. Mean calculated SQORD data for all 19 participants, based on SQORD cut-off points. Percent time with said intensity PA/Day is based on hourly cut-off points. Daily said intensity is based on daily cut-off points, as determined by SQORD.

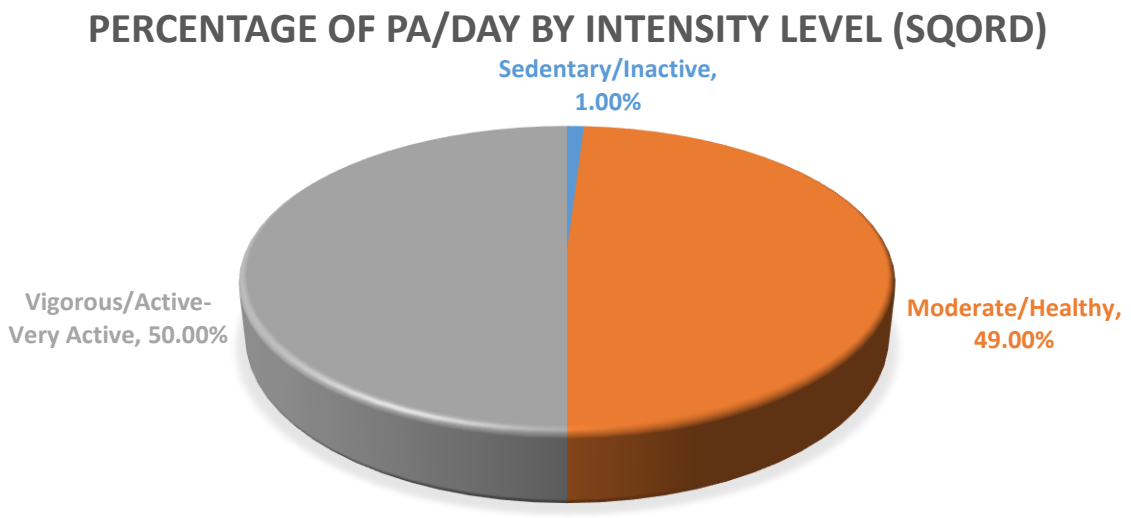

Figure 6. Percentage of PA per day by varying intensity level according to SQORD.

Accelerometers as Motivational Tools

On the daily physical activity log, participants were instructed to respond "yes" or "no" to the following question: "Did the accelerometers motivate you to exercise today?" Participants indicated that 21% of the time, the accelerometers did motivate them to exercise and 79% of the time, the accelerometers had no influence on their decision to engage in physical activity. These results are based on the average response of each participant over the course of the 4-day study period, where an answer of "yes" indicated 100% motivation and an answer of "no" indicated 0% motivation. For instance, if a participant indicated on three out of the four days that the accelerometers motivated him or her to exercise, the average response of this participant was 75% "yes" and 25% "no."

DISCUSSION

Actigraph GT3X vs. SQORD

The Actigraph GT3X is a validated PA measurement device that is routinely used to monitor PA in PA measurement studies. The results of the study, *Actigraph GT3X: Validation and Determination of Physical Activity Intensity Cut Points*, found that "the GT3X proved to be a good tool to predict EE in youth and adults" (Santos-Lozano 1). For the purpose of this study, the Actigraph GT3X was chosen as the gold-standard with which to compare the SQORD device. To decide whether the SQORD device is a reliable alternative to the Actigraph, we compared the two devices on different aspects including cost, the PA measurement information provided, method of acquiring information, and PA measurement accuracy by each device. In sum, it was found that though the SQORD device is easily accessible and user-friendly, SQORD does not provide an accurate or detailed summary of one's daily PA.

Of note, SQORD is $15/device - significantly less expensive compared to the Actigraph (~$350/device). Clearly, the SQORD is more easily accessible to families and children who wish to track their PA on a budget. Furthermore, the lower cost of the SQORD device also appeals to researchers who monitor PA in children, as there is less liability and loss associated with the SQORD device compared to the Actigraph. In addition to the ease of accessibility of SQORD, the web-based interface used by SQORD is a convenient method by which users can acquire information about their PA. Simply swiping one's wristband and logging in with a username and password is all that is required to view and analyze one's information. Actigraph is more complex, requiring purchase, activation, and installation of data analysis software to acquire PA user information. The ActiLife software also requires prior knowledge in PA terminology and

familiarity with PA measurement, whereas SQORD displays all information in the form of easy-to-read bar graphs (see Figure 4) and standard numerical activity points.

The information provided by each device varies significantly as well. The Actigraph GT3X can provide PA on a one-second interval, ten-second interval, or a one-hour interval. With this capability, therefore, one can monitor PA more closely, determining exactly when the user is idle and when the user is engaging in light, moderate, or vigorous PA. Actigraph also records acceleration on three separate axes, representing acceleration in three different directions. Cut-off points are also shown: light, moderate, and vigorous; even more specifically, Actigraph shows the three separate axes and their relative intensities which are indicated by different colors on the graph. This information provides more detail on whether the individual moves in an up-down, side-to-side, or forward-backward motion, which may be useful to researchers.

On the contrary, SQORD provides much less information, neglecting to inform the user of a highly-detailed PA profile. As seen in Figure 4, SQORD can only provide PA information in hour intervals; therefore, one cannot determine at which point in that hour he or she is most active. Rather, SQORD sums up all the activity in that hour, clumping light, moderate, and vigorous PA together. Consequently, it is only possible to determine the intensity of PA for any given hour, though the intensities may be unequally distributed. Furthermore, SQORD does not provide any form of cut-off points to its users. For the purposes of this study, it was necessary to contact Coleman Greene, the founder of SQORD, to obtain these cut-off points. Thus, qualitative analysis of SQORD PA data is not as easily accessible by researchers, and users are unable to determine the intensity of PA according to the HHS guidelines for physical activity. SQORD does not provide information about different axes of motion; thus, one cannot determine whether

the user's motion is up-down, side-to-side, or forward-backward. In sum, the SQORD device provides a simpler, less-detailed profile of its user's PA.

Due to the differences in the type of information provided, it is only feasible to compare the following qualitative data: percentage of hours spent in moderate-intensity PA and percentage of hours spent in vigorous-intensity PA. According to Actigraph, users, on average, spent 21.8% of their time in moderate-intensity PA and 6.2% of their time in vigorous-intensity PA per day. These results are reasonable as participants, on average, engaged in fewer hours of vigorous-intensity PA per day in comparison to moderate-intensity PA. According to SQORD, users spent 49% of their time in moderate PA and 0-1% of their time in vigorous-intensity PA. These results follow a similar pattern of higher moderate-intensity PA compared to vigorous-intensity PA, but the values are more extreme. This may be a result of the cut-off points provided by Coleman. Very few participants achieved hourly activity points values greater than 15,000, the minimum requirement for vigorous-intensity PA. Moreover, the range for moderate-intensity PA was greater (2,500-15,000), thus resulting in a higher percentage of moderate-intensity PA among users.

Unique to SQORD, the SQORD device also provides daily cut-off points for determining the daily intensity level of an individual's PA. According to SQORD, 36.1% of users had days characterized as sedentary/light intensity, 28.7% of users experienced days of moderate intensity, and 35.2% of users had days characteristic of vigorous intensity. These results are relatively inconsistent with the hourly percentages found among SQORD participants. Based on the mean hourly percentages, it is reasonable to suspect that most subjects would experience days of sedentary/light intensity, followed by days of moderate-intensity, and later followed by days of vigorous-intensity. Thus, there seems to be an inconsistency with the cut-off points determined

per hour and per day. It is also possible that high levels of moderate-intensity PA over an extended period of time may result in a total daily vigorous intensity.

Actigraph GT3X and SQORD Utility for Monitoring PA Guidelines

According to the data collected in this study, participants averaged about 2.7 hours, or 162 minutes, of moderate PA over the four day period. This meets the HHS PA guidelines for American adults who are encouraged to achieve about 150 minutes of moderate PA per week. Participants averaged about 0.8 hours, or 47 minutes, of vigorous PA over the four day period. These results are inconsistent with HHS PA guidelines for American adults which recommend at least 75 minutes of vigorous PA per week. However, participants may not have achieved this goal because the study was conducted over four days as opposed to seven days (one week).

One limitation of the Actigraph GT3X and SQORD devices in relation to monitoring HHS PA guidelines is their inability to distinguish between aerobic and muscle-strengthening exercises. HHS guidelines indicate ideal amounts of aerobic and muscle-strengthening PA per week- however, these are incapable of distinguishing between the two. Rather, the user must monitor and record these activities voluntarily.

Actigraph GT3X and SQORD and the FITT Principle

One method by which to compare the PA measurement of Actigraph and SQORD accelerometer devices is analyzing each device's reliability in addressing the FITT Principle. The FITT Principle is derived from two overreaching PA principles: overload and progression. Overload is defined as the added resistance to the body outside normal resistance, and progression refers to the method by which one increases this resistance. Progression is further

divided into four components that make up the FITT Principle: frequency, intensity, time, and type or specificity (AAHPERD 1).

Components of the FITT Principle	
Frequency	How often a person performs the targeted health-related physical activity (AAPHERD)
Intensity	How hard a person exercises during a physical activity period (AAPHERD)
Time	Length of the physical activity (AAPHERD)
Type (specificity)	Specific physical activity chosen to improve a component of health-related fitness; i.e., an individual wishing to increase aerobic endurance needs to jog, run, or swim (AAPHERD)

Table 5. Components of the FITT Principle and their definitions.

In assessing how the Actigraph and SQORD accelerometers address each of these components, the effectiveness by which each accelerometer measures PA for the purpose of PA progression in an individual can be determined. The Actigraph GT3X calculates and provides the raw data for time and intensity of PA. From the time data, one can calculate the frequency of an individual's PA as well. On the contrary, SQORD does not provide detailed length of PA or intensity level- activity point cut-off levels are not accessible by the user and one cannot lessen the time increments of recorded PA. Thus, frequency is incalculable. In addressing the FITT principle, the Actigraph GT3X performs superiorly to SQORD, thus providing its user with a more comprehensive and accurate PA measurement. For both devices, the component of PA "Type" must be recorded voluntarily by the user, as the devices are incapable of distinguishing between different types of PA. Though Actigraph does not provide the user with a means to record PA type in the device, the SQORD web interface allows the user to record PA type for

each hourly block. It is essential that a PA measurement device fulfill all components of the FITT principle to provide its user with the most accurate and thorough PA profile.

Limitations

The results of this study were influenced by the limitations of this study. One of the greatest limitations was sample size and specificity. To obtain more comprehensive results from the comparison of the Actigraph GT3X and SQORD, it would have been beneficial to extend the sample size to include children (individuals under the age of 18) and older adults (individuals over the age of 30). The age parameters of this study limited the sample size and resulted in a highly specific sample of individuals.

Another limitation to this study was the duration of data collection. Instead of monitoring PA for four days, it would have been useful to collect data for a total of one week, or seven days. However, due to data storage constraints in the SQORD device, the study protocol was not conducive to performing a seven-day PA data collection. Indeed, monitoring PA for one week would have provided a more comprehensive PA profile for the participants in this study and allowed better comparison to national PA guidelines.

Further limitations included the inability of the SQORD and Actigraph devices to accurately record certain types of PA because of the position in which each device was placed. For instance, the Actigraph was incapable of accurately recording muscle-strengthening PA due to its placement above the hip bone. Therefore, muscle-strengthening exercises such as bench press and free weights were not recorded in the given exercise bout. On the other hand, because the SQORD device was placed on the wrist, the SQORD device was incapable of recording aerobic exercises such as cycling due to the constant immobility of the wrists and arms.

Limitations regarding placement of each device were unavoidable as each device is designed especially for placement in their respective areas.

A limitation encountered during data analysis was the time increment differences provided by the Actigraph GT3X and SQORD. Because SQORD presented PA data in a larger time increment, it was difficult to compare to the more detailed accounts provided by the Actigraph GT3X. This discrepancy in data representation may have been one reason for such large differences in data, as SQORD did not allow for PA analysis within each hour block. SQORDs limited capacity in data recording served as a major limitation in conducting this experiment and achieving comprehensive results.

CONCLUSION

In conclusion, it was determined that SQORD did not perform to the same level as the Actigraph GT3X, suggesting SQORD is not a reliable alternative to the Actigraph GT3X in measuring one's PA. The Actigraph GT3X out-performed the SQORD in terms of the more detailed PA profile it provided to quantify and give users feedback on their PA, its greater success in addressing all components of the FITT Principle, and its better utility in comparing PA measurements to standard PA guidelines.

APPENDIX

Additional Reference Tables and Figures

002 (Captain Guide1) Sqord Activity Points														
	Time	8:40 AM	9:40 AM	10:40 AM	11:40 AM	12:40 PM	1:40 PM	2:40 PM	3:40 PM	4:40 PM	5:40 PM	6:40 PM	7:40 PM	8:40 PM
Date	17-Feb-14	START	3388	1682	3476	2986	3680	*5340	1122	*4528	2280	4770	0	0
	18-Feb-14	0	*4794	4286	3934	3682	*4512	*7110	1518	2214	738	*3036	1904	0
	19-Feb-14	0	*4164	*10276	3214	3008	3968	1474	3730	4172	3126	7928	0	0
	20-Feb-14	0	4684	4436	4588	3416	2572	4426	3314	*5680	3708	3748	*5360	3330
	21-Feb-14	0	218	5300	END									

Table 2. SQORD activity points by hour for participant 002 over the course of 4-day study. An asterisk (*) denotes moderate-intensity PA and double asterisk (**) denotes vigorous-intensity PA (based on Actigraph cut-off points).

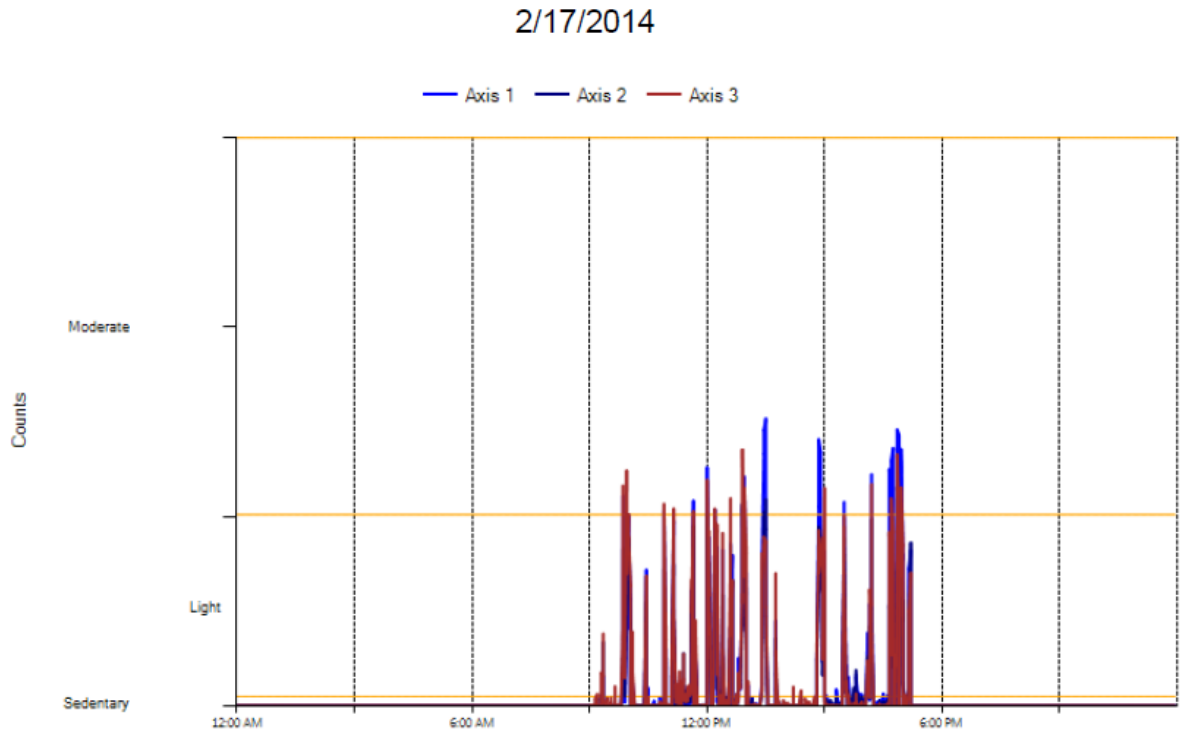

Figure 2-1. Actigraph cut-off points and activity counts by hour for participant 002 on day 1 of the 4-day study. Yellow lines indicate borders of cut-off points. Highest yellow line represents vigorous-intensity PA.

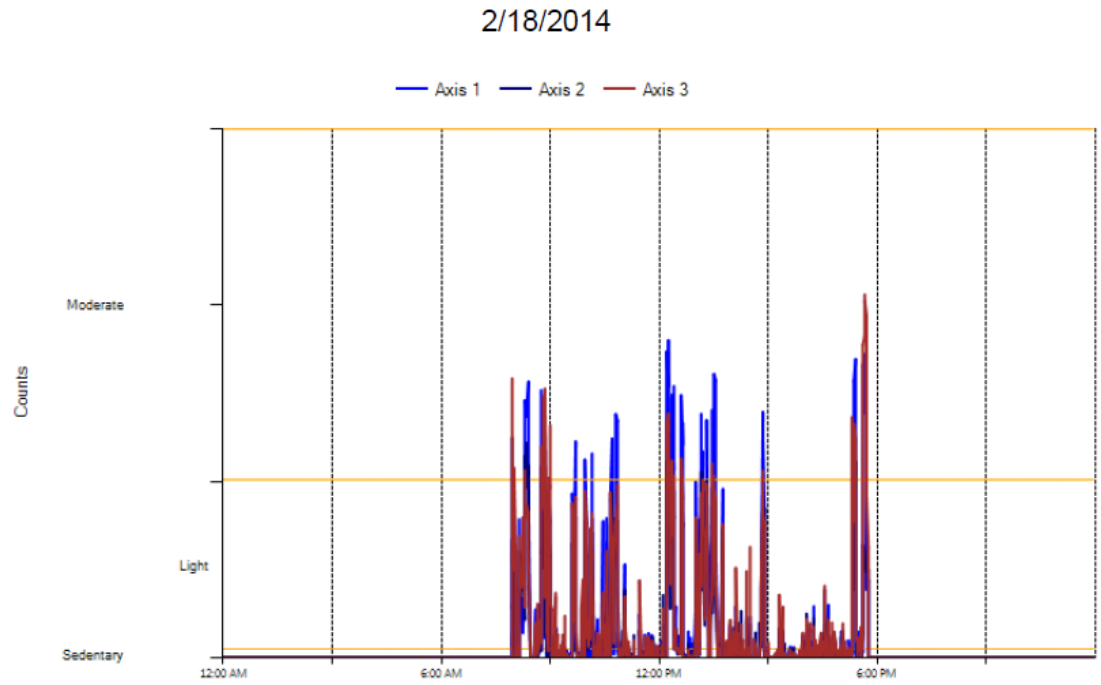

Figure 2-2. Actigraph cut-off points and activity counts by hour for participant 002 on day 2 of the 4-day study. Yellow lines indicate borders of cut-off points. Highest yellow line represents vigorous-intensity PA.

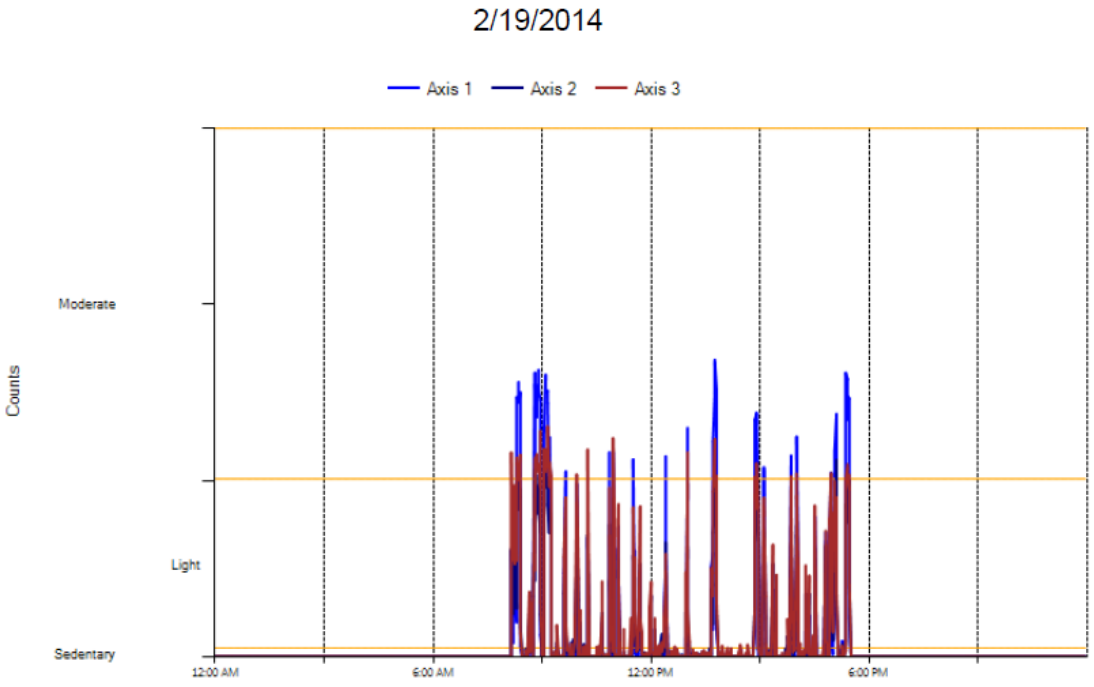

Figure 2-3. Actigraph cut-off points and activity counts by hour for participant 002 on day 3 of the 4-day study. Yellow lines indicate borders of cut-off points. Highest yellow line represents vigorous-intensity PA.

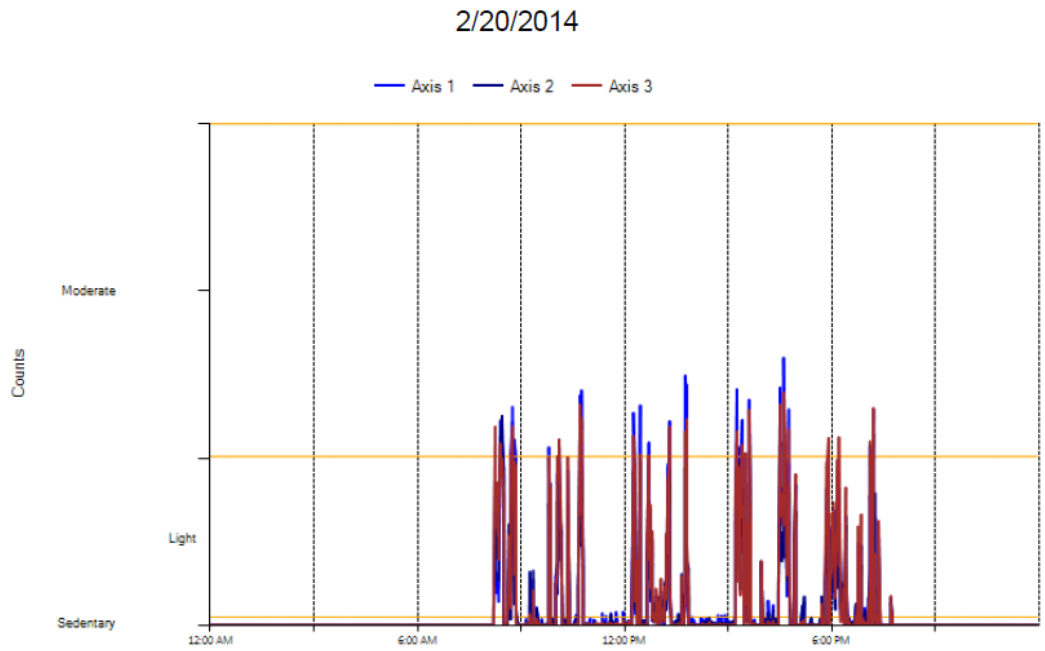

Figure 2-4. Actigraph cut-off points and activity counts by hour for participant 002 on day 4 of the 4-day study. Yellow lines indicate borders of cut-off points. Highest yellow line represents vigorous-intensity PA.

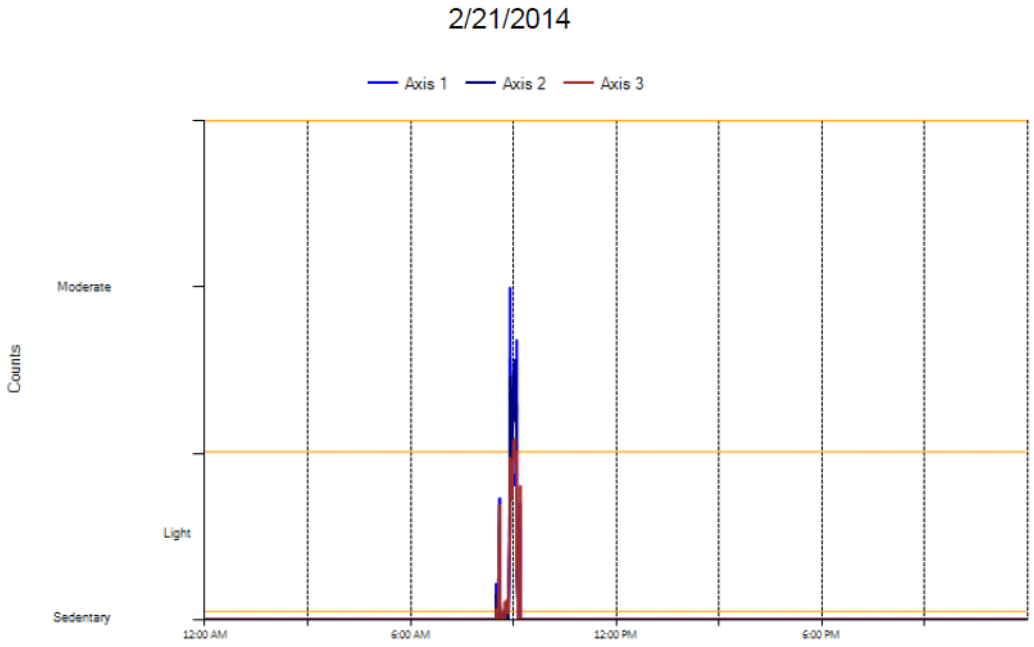

Figure 2-5. Actigraph cut-off points and activity counts by hour for participant 002 on day 4 of the 4-day study. Yellow lines indicate borders of cut-off points. Highest yellow line represents vigorous-intensity PA.

Estimates of Activity Threshholds					
	Sedentary	**Inactive**	**Healthy**	**Active**	**Very Active**
Activity Points/Day	10,000	20,000	40,000	60,000	80,000
Steps (Est.)	3,000	6,000	12,000	18,000	24,000
Vigorous Hour					
Activity Points (Est.)	25,000				
Activity Points Measured	15,000				
Sqord will Credit					
Confirmed 60 Minutes of Moderate to Vigorous Activity			15,000 Activity Points in any one-hour block of activity when immediately preceeded or followed by a block of at least 10,000 Activity Points.		
Estimated 60 Minutes of Moderate to Vigorous Activity			35,000 Activity Points in a day, when a maximum of three one-hour blocks add up to 25,000 Activity Points.		
Confirmed Healthy Day of Activity (Target)			40,000 Activity Points in a day.		
All threshholds subject to adjustment as real-world results come in.					

Figure 3. Cut-off points for SQORD device. Note: hourly moderate PA cut-off points of 2500-15,000 were determined by dividing minimum vigorous intensity (60,000) by 24 hours to give 2500 points as the minimum for moderate intensity PA. 15000 is the minimum cut-off point for vigorous PA as determined by Coleman.

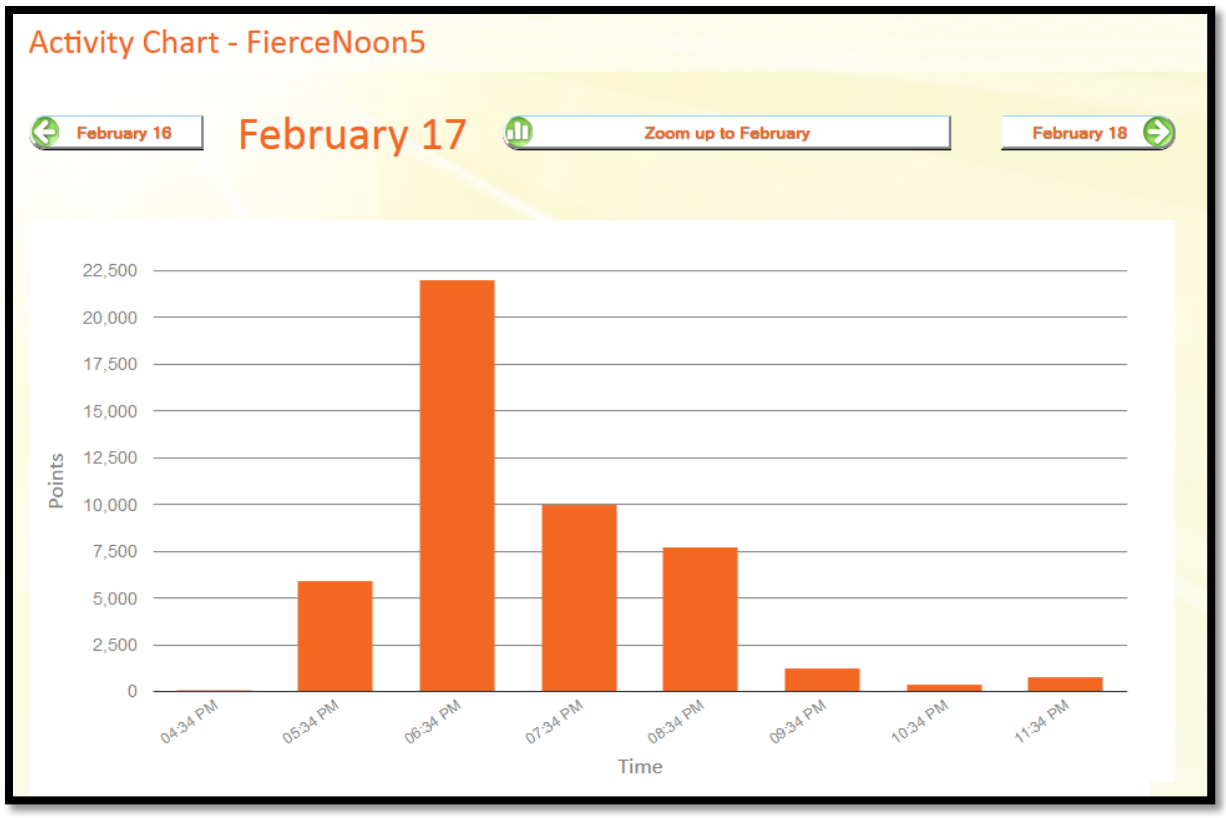

Figure 4. SQORD web-interface "Activity Points" display. Points are divided into one hour increments.

References

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