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Tingting Xu
Stephen F. Austin State University, xut@sfasu.edu

Erik Jon Byker
University of North Carolina at Charlotte

Monica Rae Gonzales
Lone Star College

USING WIRELESS PEDOMETERS TO MEASURE CHILDREN'S PHYSICAL ACTIVITY: HOW RELIABLE IS THE FITBIT ZIP™?

Tingting Xu[1], Erik Jon Byker[2*], and Monica Rae Gonzales[3]

[1]Stephen F. Austin State University, Nacogdoches, Texas, United States
[2]University of North Carolina at Charlotte, North Carolina, United States
[3]Lone Star College at University Park, Houston, Texas, United States

*Email: ebyker@gmail.com, ebyker@uncc.edu
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Abstract

The purpose of this study is to examine the reliability of wireless pedometers in measuring elementary school children's physical activity. Activity measurement using a wireless pedometer Fitbit Zip™ was compared to activity measurement using Yamax Digi-Walker™ SW701 for a group of randomly selected 25 children in Grades 3, 4, and 5. Fitbit Zip™ wireless pedometers were found to have an appropriate degree (Nunnally & Bernstein, 1994) of accuracy and reliability compared to the Yamax Digi-Walker™ SW701 pedometer. The Fitbit Zip™ wireless pedometer collected more step counts than the Yamax Digi-Walker™ SW701 pedometer; however, the difference was not statistically significant. Participants reported that they preferred wearing the Fitbit Zip™ to the Yamax Digi-Walker™ SW701 because the Fitbit Zip™ was more comfortable to wear and less likely to fall off. Participants also reported being more motivated to move while wearing the Fitbit Zip™.

Keywords: Elementary school, physical activity, physical education, wireless pedometry

Introduction

Wearable technologies, like wireless pedometers, are promising ways to get children moving through physical activity and kinesthetic learning. Yet, more and more school districts across the United States cut their physical education programs in elementary schools in favour of standardised test review (Kohl & Cook, 2013). Added to this conundrum is the fact that childhood obesity continues to be a serious health problem throughout the United States (Crespo, Smit, Troiano, Bartlett, Macera, & Andersen, 2001; Dietz & Gortmaker, 2001). Researchers have found that pedometers are suitable (Clemes

& Biddle, 2013) tools to measure the physical activity of children. Indeed, pedometers have been frequently used to assess physical activity in children because they are accurate, low-cost, and easy to use (Tudor-Locke, Williams, Reis, & Pluto, 2002; Vincent & Pangrazi, 2002). They objectively measure the accumulated physical activity and have been tested to be reliable and valid with elementary-school children (Clemes & Biddle, 2013; Eisenmann & Wickel, 2005; Rowe, Maha, Raedeke, & Lore, 2004). Among various types of pedometers available, the Yamax Digi-Walker™ SW701 (Yamax Corp., Tokyo) pedometer has been research validated as the most accurate pedometer in measuring physical activity (Bassett et al., 1996). In field tests, the Yamax Digi-Walker™ has been found to be the most accurate and reliable of 20 different models of pedometers (Crouter, Schneider, Karabulut, & Bassett, 2003; Schneider, Crouter, Lukaji, & Bassett, 2003). The Yamax Digi-Walker™ was also found to have high inter-instrument reliability (r = .95) in a study that involved elementary school children (Barfield, Rowe, & Michael, 2004). Therefore, physical activity researchers have widely recognised the Yamax Digi-Walker™ for its step accuracy and the device is commonly used to measure physical activity in elementary school students.

Wireless digital pedometers, like the Fitbit Zip™ (Fitbit, Inc. San Francisco, CA), have become increasingly popular. Wireless pedometers can track and offer real-time data on many statistics including a number of steps a user has taken, the distance and the speed the person has walked/run, as well as the number of calories burned. The Fitbit Zip™ wireless pedometer, for example, uses digital sensors that can track the steps, distance, and calories burned. These data are automatically synchronised to a laptop or tablet. While wireless pedometers offer many advantages, there have only been a few studies of their reliability and these studies have mixed results (Dannecker, Sazonova, Melanson, Sazonov, & Browning, 2013; Ertzberger & Martin, 2016; Lee, Kim, & Welk, 2014). Studies by Xu, Byker, and Gonzales (2017) and Erzberger and Martin's (2016) show increased motivation for physical movement among classroom students and teachers when wearing wireless pedometers. There is a gap in the literature regarding the reliability of wireless pedometers with children in the natural school setting. Therefore, this study addresses that research gap by examining the reliability of Fitbit Zip™ wireless pedometer in measuring children's physical activity in comparison to the Yamax Digi-Walker™ SW701. The study is guided by three research questions:

1) How reliable are wireless Fitbit Zip™ pedometers in measuring the physical activity of elementary students?
2) How do wireless Fitbit Zip™ pedometers compare to the Yamax Digi-Walker™ SW701 analogue pedometers in accurate measurement of counting steps?
3) What are the elementary students' perceptions and attitudes about wearing wireless Fitbit Zip™ pedometers in the school setting?

Methods

This study utilises a mixed methods design. Mixed-methods research "includes the collection and analysis of both qualitative and quantitative data" (Creswell, 2014, p. 217) in order triangulate findings. The study's qualitative data provides rich descriptions of

the participants' perceptions about the differences between the Fitbit Zip™ wireless pedometers compared to the Yamax Digi-Walker™ SW701. The quantitative data provides ways to test the reliability of the Fitbit Zip™ wireless pedometers, using the Yamax Digi-Walker™ SW701 as the criterion measure. Data were collected after the researchers gained human subject research permission given from the University Institutional Review Board (IRB). Before the research began, consent and assent forms were filled out by the school principal, parents, and students.

Participants

A convenience sample of children was recruited from Grade 3, Grade 4, and Grade 5 at a charter elementary school located in East Texas. Participants included 13 boys and 12 girls, ranging in age from 8 to 11 years old. In sum, the participant sample was 25 children (n=25). See Table 1 for a demographic description of the participants.

Table 1: Description of Participants

Grade	Female	Male	Total
3rd	3	2	5
4th	6	6	12
5th	3	5	8
Total	12	13	25

Data Sources

There were two types of pedometers used in this study for physical activity measurement: the Fitbit Zip™ wireless pedometer and the Yamax Digi-Walker™ SW701 analogue pedometer. The quantitative data were derived from the accuracy and reliably tests of the Fitbit Zip™ wireless pedometers. Over a six-week period, the study's participants wore the two pedometers simultaneously. The Yamax Digi-Walker™ SW701 was the study's criterion measure. Before the study, participants were taught the appropriate way to wear each of the pedometers. They were allowed to see the inside of the Yamax Digi-Walker™ SW701 and explore the Fitbit Zip™ screen. The participants arrived at the school's morning check-in around 7:40 am, and they attached both numerically assigned pedometers to the waist band of the pants or shorts that they wore to school. They wore the pedometers for four days a week from the time they arrived at school in the morning to the time they were released in the afternoon. The Yamax Digi-Walker™ SW701 pedometers were not sealed for the convenience of installing, retrieving, and recording the step data; however, children were encouraged to ignore the pedometers as they went throughout their normal school days. When they turned in the pedometers at the end of the school day, the participants' step counts from the Yamax Digi-Walker™ SW701 were recorded on a spreadsheet, and the pedometers were reset to zero. The Fitbit Zip™ step data were synchronised on a laptop computer.

There were two qualitative data sources. First, field notes were taken and organised by time notations. The second source of data came from focus group interviews. A focus group interview was conducted with small groups (between 5-10) of students at each grade level of the study (i.e., Grades 3, 4, and 5). The interview was semi-structured

using an active interview approach (Holstein & Gubrium, 1995). The participants were asked questions regarding the degree to which wearing the wireless pedometers affected their motivation and overall physical activity.

Data Preparation and Treatment

Quantitative data were first organised in Microsoft® Excel® 2011(Microsoft Corporation, Redmond, WA). All missing data and outliers were then treated for data analysis. Based on suggestions from the field, daily step counts that were lower than 1000 and over 30,000 were treated as missing data (Rowe, Mahar, Raedeke, & Lore, 2004). Data from the first week were treated as baseline data and was excluded from data analysis. Step data on Day 15 and Day 16 were excluded due to reason that participants were taking the state standardised test on these two days. All statistical analyses, then, were carried out using SPSS version 20 (SPSS, Inc., Chicago, IL) and significance of results was evaluated at the .05 alpha level. Reliability of step counts from both pedometers was estimated by using intraclass correlation coefficients (ICCs) and the 95% confidence interval (CI) for the ICCs. Based on the reliability cut point indicated by previous studies, the minimally acceptable reliability should be $r \geq .70$, and the more appropriate reliability should be $r \geq .80$ (Nunnally & Bernstein, 1994).

Qualitative research methods were also tools used in the analysis. The field notes and interviews were analysed using a three-step interpretive approach (Miles & Huberman, 1994). Data were first transcribed and read in their entirety. Then the data were organised according to categories and compared using the constant-comparative method (Glaser & Strauss, 1967). Frequencies in the data were further analysed to establish patterns in the data. While reading the data and using the initial broad categories, patterns and themes were made into codes. Charts and meta-matrices were created to compare, contrast, and probe for additional themes across the data (Miles & Huberman, 1994). The quality of data coding was assessed by researchers using a random selection of 25% of transcriptions, and it arrived over 95% agreement.

Findings

In sharing the findings of the research, the authors address the three research questions in order. First, the study reports on the intraclass correlations (see Table 2) reliability of the wireless Fitbit Zip™ pedometers in measuring elementary students' overall physical activity during the school day. Second, the study describes the accuracy (see Table 3) of the wireless Fitbit Zip™ pedometers compared to the Yamax Digi-Walker™ SW701 analogue pedometers. Third, the study examines elementary school participants' perceptions about wireless pedometers.

Table 2: Intraclass Correlations (ICCs) and 95% Confidence Intervals (CI) from day 5 to 24

Day	ICCs	95% CI
5	.865	.689 - .942
6	.764	.433 - .902
7	.812	.565 - .919
8	.836	.604 - .932
9	.861	.673 - .941
10	.956	.897 - .982
11	.806	.533 - .920
12	.910	.788 - .962
13	.918	.799 - .967
14	.918	.799 - .967
17	.816	.558 - .924
18	.887	.708 - .957
19	.796	.518 - .913
20	.372	-.630 - .758
21	.632	.093 - .851
22	.775	.431 - .911
23	.713	.308 - .881
24	.691	.239 - .875

First, the Fitbit Zip™ wireless pedometers were found to have an appropriate degree of accuracy and reliability in comparison to the Yamax Digi-Walker™ SW701 pedometer. Table 2 shows the intraclass correlations (ICCs) that were calculated to estimate the reliability of Fitbit Zip™ pedometer. The reliability indices varied from .372 to .956, with the lowest reliability of .372 with 95% CI [-.630, .758] occurring on Day 20 and the highest reliability of .956 with 95% CI [.897, .982] occurring on Day 10. Based on the cut point of reliability index of r =.70 (Nunnally & Bernstein, 1994), Day 20 reliability index was the lowest, Day 21 reliability index was a little lower than .70, and Day 24 was close to .70. On other days, the reliability indices were more than .70. Overall, the Fitbit Zip™ averaged a .796 on the reliability indices, which indicates that was above what is minimally acceptable reliability (r =.70) and it almost met the appropriate reliability of $r \geq .80$ (Nunnally & Bernstein, 1994). Thus, the Fitbit Zip™ pedometer is considered a reliable pedometer in terms of measuring steps among elementary school students.

A second finding is that while the Fitbit Zip™ wireless pedometer collected more step counts than the Yamax Digi-Walker™ SW701 pedometer; the difference was not statistically significant. The over-reporting of Fitbit Zip™ is consistent with the much of the anecdotal comments from blogs on the Internet. Table 3 presents the daily mean step counts for Yamax Digi-Walker™ SW701 and Fitbit Zip™, and the mean differences in step counts between these two pedometers.

Table 3: Mean Step Counts between the Fitbit Zip™ and the Yamax Digi-Walker™ SW701

Days	Yamax Digi-Walker™ SW701 Mean step counts	Fitbit Zip™ Mean step counts	Differences (Yamax Digi-Walker™ SW701-Fitbit Zip™)	t	Sig.
5	4534.29	4546.38	-12.083	-.051	.960
6	4457.45	4574.00	-116.545	-.414	.683
7	5512.13	5678.92	-166.792	-.638	.530
8	4588.48	4948.83	-360.348	-1.012	.323
9	5671.61	5532.22	139.391	.680	.504
10	5714.95	6058.64	-343.682	-.910	.373
11	6067.13	6086.30	-19.174	-.070	.945
12	4948.36	5258.55	-310.182	-.703	.490
13	6372.14	5988.95	383.19	1.499	.149
14	6372.14	5988.95	383.19	1.499	.149
17	7235.77	7915.45	-679.682	-1.207	.241
18	5835.79	5850.47	-14.684	-.056	.956
19	6524.89	6525.04	-.217	-.001	.999
20	6954.89	6239.95	714.947	1.111	.281
21	6140.24	6405.29	-265.048	-.713	.484
22	6011.75	5416.15	595.600	1.999	.060
23	6512.00	5935.18	576.818	1.021	.319
24	5981.33	6468.29	-486.952	-1.279	.216

Fitbit Zip™ pedometer collected more step counts than Yamax Digi-Walker™ SW701 did. Among 60% of days in data collection, the mean step counts collected by Fitbit Zip™ were slightly higher than those by Yamax Digi-Walker™ SW701. However, these differences were not statistically significant.

The third finding related to this study was participants' perceptions of wearing the two pedometers, especially the perceptions of wearing the Fitbit Zip™ pedometers. The participants preferred wearing the Fitbit Zip™ to the Yamax Digi-Walker™ SW701 because the Fitbit Zip™ was more comfortable to wear and "they did not bother you or anything." For example, one of the participants reported that "Sometimes I didn't feel like I had it [Fitbit Zip™] on." Also, almost all the participants agreed that wearing the Fitbit Zip™ enhanced their motivation for meeting their fitness goals. For example, one participant explained that the Fitbit Zip™ "made me want to step more and make goals and like get those goals, like I might want to get 10,000 steps in a day." Another participant also reported that "it made me want to get 10,000 steps which I only did once, but it was fun." Some other participants also shared similar perceptions related to feeling motivated from wearing the Fitbit Zip™ pedometers. One of the participants shared about having a daily goal of "beating my step record from the previous day."

Participants were curious to find out about the steps they accumulated during the day, but at the same time, they also observed inconsistency in the step counts collected by both pedometers. A third grader, for example, reported how the Yamax Digi-Walker™ SW701 "is usually a little bit lower and the green one [Fitbit Zip™] is generally just a little bit higher." Another third-grade participant also noticed occasional inconsistency among the two pedometers. One participant in the fourth grade shared an incident of

concern and explained, "well one day, my friend and I only had 500 steps on the black ones [Yamax Digi-Walker™ SW701] and had something like 3,000 on the green ones." Overall, though, there were minimal reports from participants of step count inconsistency. Such reports were isolated incidents rather than a pattern of measurement inconsistencies.

Discussion

This study examined the reliability of the FitBit Zip™ in measuring elementary school children's physical activity. In comparison to the popular Yamax Digi-Walker™ SW701 analogue pedometer, this study found the FitBit Zip™ wireless pedometer to be an accurate and reliable instrument for physical activity measurement. As the wireless pedometer technology continues to improve, the study's researchers expect that the reliability and accuracy of the FitBit Zip™ will also improve. For future studies, it would be interesting to test the reliability of wireless pedometers with older adolescents in middle and secondary schools as well as with an early childhood population. The wider age range will enhance and broaden the understanding of the effects of wearable technologies (Fulton et al., 2001; Sirad, Trost, Pfeiffer, Dowda, & Pate, 2005). Moreover, as wearable technologies—like wireless pedometers—continue to develop and improve other physical activity measurements can be included in future studies. The inclusion of heart rate monitoring and caloric expenditure are additional measures that have the potential to impact motivation and will likely provide researchers additional layers of understanding physical activity. Future research is also needed to test and measure the degree of reliability with any of these new types of applications in wearable technologies. For such studies, it may be necessary to add multiple digital pedometers or accelerometers to minimise the effects of discrepancies in data sets and provide more accurate and comprehensive observations in each set of step counts.

Although this current study only examined step counts, Fitbit Zip™ wireless pedometers do provide a synchronised way to collect all types of data about children's physical activity including overall steps, distance, and calories burned. The Fitbit Zip™ wireless pedometer shows the intensity of steps any time during the monitored period along with the total number of steps collected. This function can benefit researchers who intend to examine children's physical activity levels when engaging in diverse types of activities during the school day. It also can benefit practitioners who want to increase children's physical activity to minimise their sedentary time during the school day. More research is needed into the technological applications of other functions provided by Fitbit Zip™, especially for physical education or other physical activity related purposes.

Pedagogy in Twenty-First century has increasingly shifted towards digital technologies. It is important that the study of physical activity keep up with this shift (Beetham & Sharpe, 2013). Therefore, this current study is significant because it marks the first study to provide evidence of the accuracy and reliability of the Fitbit Zip™ wireless pedometers among elementary school learners. The study marks a shift in wearable technologies from analog-based systems to digitally based systems like Fitbit Zip™ wireless pedometers. The study contributes to the existing literature in the fields of physical activity and educational technology by reporting on the relationship between

wireless pedometers and physical activity motivation among elementary school students. The study included the perspectives and voices of the elementary school children. Indeed, this study extended the knowledge of elementary school r and children's attitudes about wearing wireless pedometers and they shared how the Fitbit Zip™ wireless pedometer was a motivating factor for them in the accumulation of more steps. This finding is supported by research that found a significant increase in young learners' physical activity when using pedometers to promote physical activity among youth (Lubans, Morgan, & Tudor-Locke, 2009). Another group of researchers—who systematically reviewed 26 studies using pedometers—further support the findings that pedometers were associated with an increase in physical activity and with an increase in daily step counts among younger pedometer users (Bravata et al., 2007).

The findings from this current study correspond to these earlier studies but also add new findings in regard to the uses for wireless pedometers. Indeed, this study found that wireless pedometers— like the Fitbit Zip™ —are an effective and reliable tool to measure elementary school students' physical activity during the school day. One beneficial outcome of wearing a wireless pedometer seems to be that it is also a motivating factor towards an increase in physical activity. This motivation can be further maximised when physical activities goals are set, reflected on, and refined (Tudor-Locke, Myers, & Rodger, 2000). Since there are only a handful of studies that are focusing on the use of pedometers to promote physical activity among young children, there is a need to increase the body of knowledge in this particular field.

Conclusion

The purpose of this study was to examine the reliability of Fitbit Zip™ in measuring elementary school students' physical activity. Findings from this study suggested that the Fitbit Zip™ wireless pedometer possesses a certain degree of internal consistency reliability with high intra-class correlations. Based on the reliability index for all days, the Fitbit Zip™ shows a high reliability in step counts with reliability coefficient alpha in the acceptable range. It indicates that Fitbit Zip™ collects step data as accurately as Yamax Digi-Walker™ SW701 does. In conclusion, the strong correlation between Yamax Digi-Walker™ SW701 pedometer and Fitbit Zip™ pedometer measures suggest that the Fitbit Zip™ pedometer can be useful in providing an objective measure of activity levels and feedback on children's physical activity patterns. Therefore, Fitbit Zip™ is considered as a reliable measurement for children's physical activity step counts.

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