The Swedish Journal of Scientific Research

Original Article

The Effect of a Wrist Worn Accelerometer on Children's In-School And Out-of-School Physical Activity Levels

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ABSTRACT

Background: Children's physical activity levels continue to decline with age. Wrist worn accelerometers are accessible and worn by many children; however, research examining the effects of wrist worn accelerometers on children's physical activity levels has not been conclusive. **Methods:** 25 children were given a wrist worn accelerometer for 4 weeks (1 week sealed; 3 weeks unsealed) and information about physical activity and fitness to increase their in- and out-of school physical activity. **Results:** Multivariate analysis revealed a significant difference for in-school (p=.021) and out-of-school (p=.012) activity between weeks 2 and 3, suggesting reactivity to the wrist worn accelerometer. Males were significantly more active out of school (p=.017). Additionally, our results indicated that Asian students [M=7879.6(±481.1)] were getting significantly fewer *moves* than African American students [M=9439(±367.5)]. **Conclusions:** This study demonstrated that the use of activity trackers and information alone could not be sufficient in improving physical activity levels among 5th graders.

Keywords: Out-of-school physical activity, activity trackers, self-regulation

INTRODUCTION

Health benefits from engaging in regular physical activity have been well documented (Centers for Disease Control and Prevention, 2015). Regular physical activity (i.e. 60 minutes on most days of the week) aids in the growth and development of children and is associated with psychological benefits for youth regardless of weight status (Calfas & Taylor, 1994; Haugen, Säfvenbom, & Ommundsen, 2011; Digelidis, Papaioannou, Laparidis, & Christodoulidis, 2003). Although the benefits of physical activity are well known, reports suggest that only 58% of children are meeting physical activity recommendations and levels of physical activity continue to decline as children age (Troiano et al., 2008; Baranowski, Thompson, DuRant, Baranowski, & Puhl, 1993). Establishing physical activity behavior early in life is key, because regular physical activity behavior and skills developed in childhood and early adolescence are likely to translate into adulthood (Institute of Medicine, 2012).

On average, children in the United States spend 6.64 hours per day in school (U.S. Department of Education, 2008); therefore, schools should be targeted for physical activity promotion programs. Public health efforts have increased physical activity during physical education, but 60 minutes of physical activity cannot be met in physical education alone (Palmer & Bycura, 2014). Furthermore, it has been reported that only 35.3% (19) of states are requiring elementary students to participate in a specific number of physical education minutes per week, and only 6 states are requiring 150 minutes or more per week (SHAPE

Access this article online

Website: http://sjsr.se/

ISSN: 2001-9211

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America, 2016). This data and the lack of children meeting physical activity guidelines highlights the need for quality physical education classes to provide learning opportunities on how children can be more physically active outside-of-school (Chen, Kim, & Gao, 2014; Institute of Medicine, 2012). This objective has been highlighted by national physical education teaching standards and public health (SHAPE America, 2016).

Previous literature suggests the establishment of self-regulation skills may impact out-of-school physical activity (Butcher, Fairclough, Stratton, & Richardson, 2007). Within the context of Bandura's social cognitive theory, self-regulation involves three principles including: self-monitoring of one's behavior, judgment of one's behavior in relation to personal and environmental standards and expectations, and self-reaction to one's behaviors (Bandura, 1991). The utilization of an activity tracker can provide all three aspects of self-regulation. First, the activity tracker can monitor a child's physical activity patterns. Second, the tracker can provide feedback by providing children with immediate information about their physical activity and can act as an environmental cue or reminder to engage in more physical activity (Tudor-Locke, 2002). Finally, the tracker may encourage self-reaction to enhance children's ability to self-regulate their own physical activity. The majority of physical activity tracker literature is being conducted to estimate energy expenditure (Puyau, Adolph, Vohra, Zakeri, & Butte, 2004; Stookey, Mealey, & Shaughnessy, 2011) and to estimate the validity and reliability of the tracker themselves (Rowe, Mahar, Raedeke, &Lore, 2004; Clemes & Biddle, 2013). A study examining the feasibility of wearing activity trackers, suggested that children preferred the wrist-worn activity trackers (23 out of 24 children) with the two most prominent reasons being comfort and the feedback feature (Shaefer & Marta Van Loan, 2014). When examining the use of activity trackers in physical activity interventions with adults, it has been suggested that activity monitoring can increase awareness and support physical activity behavior within the intervention (de Vries, Kooiman, van Ittersum, van Brussel, & de Groot, 2016).

In addition to a fitness tracker, adequate health-related fitness knowledge would be necessary for a child to determine environmental and personal standards, the second aspect of self-regulation. Keating et al., 2009 reported deficiencies in health-related fitness knowledge among students at all educational levels. Therefore, the purpose of this study was to determine the effects of providing elementary students with wrist worn accelerometer and information about physical activity and fitness on increasing their in- and out-of school physical activity.

METHODS

Participants and Setting

Students were recruited from a local elementary school in the Southeast United States. All students in one 5th grade physical education class (ages 10-12 years) were invited to participate. This class consisted of three homeroom classrooms for a total of 40 children. Forty children provided parental consents and assented to be in the study. Ethical approval was obtained from the university's Human Research Ethics Committee prior to recruitment. The physical education class was five days per week and 30 minutes in duration.

Physical Activity Tracker

Each student was asked to wear the *MOVABLE* MOVband3, wrist-worn, activity tracker (*Dynamic Health Solutions*, *LLC*, Houston, Texas). The MOVband3 utilizes tri-axial accelerometry and demographic information to estimate "moves" or physical activity during a 24-hour period. Approximately 12,000 *moves* is the equivalent of 10,000 steps (*DHS Group*, Houston, Texas). The MOVband3 has companion software that can estimate physical activity in 1-hour intervals. Each participant's demographic information (height, weight, birth date, and sex) was used to calibrate the activity tracker. Activity trackers were downloaded each week. Physical activity data from Tuesday, Wednesday, and Thursday each week were analyzed.

Health-Related Fitness Knowledge

Prior to instruction, all students completed a validated, grade appropriate test of health-related fitness knowledge (Chen, Chen, Sun, & Zhu, 2013; Zhu, Safrit, & Cohen, 1999). This test has 11 multiple choice questions sought to determine students' knowledge of four areas of fitness: (i) FITT (frequency, intensity, type, and time) principles, (ii) training principles of overload, progression, and specificity, (iii) health-related fitness components, and (iv) parts of a workout (e.g., warm-up, cool down). The test has two equivalent forms (form A vs. form B). Students completed version A at pretest and version B at posttest.

Physical Activity Opportunities at School

For this elementary school there were two blocks per day scheduled for physical activity: a 30-minute physical education block and a 15-minute afternoon recess block. In physical education the students participated in a fitness unit led by the certified physical education teacher. The unit included daily instruction on key components of fitness (e.g., progression, overload, FITT principle) in a participatory format. Specifically, a typical day consisted of a brief teacher introduction and demonstration of how a fitness component could be incorporated with an exercise, followed by students creating their own exercises applying the fitness component in groups, and finally all students participating in each group's exercise in station rotations. The 15-minute recess block consisted of outdoor free play on a playground area. The children had access to balls, climbing structures and green space. Over the course of the three weeks, recess was conducted outside except for three days. Two days recess was conducted inside due to weather and consisted of social based activities, with minimal movement. One day of recess did not occur due to a school wide activity.

Procedures

Height and weight was assessed with a calibrated electronic scale (Michelli Scales, Harahan, LA) to the nearest 0.1 kg and height measured to the nearest 0.25 on a calibrated scale and standiometer. Students were given the activity trackers on Monday morning at 7:45am and were asked to return them Friday morning at 7:45am. Students were instructed to wear the activity tracker at all times throughout the day, with exceptions being during any water-based activities. Students were given sealed activity trackers so they were unable to see their "moves" for baseline measurement for 1 week. For the following 3 weeks, students were given unsealed activity trackers and instructed on how to monitor and interpret their "moves" on the screens.

Statistical Analysis

School days began at 7:30am and ended at 2:45pm. For data analysis purposes, "in-school" time was defined as 7:00am-2:00pm and "out-of-school" time was from 3:00pm-10:00pm. Physical activity data was broken down into hourly segments, with 2:00pm activity representing physical activity taking place between hours 2:00-2:59pm. If a participant had more than 1 day per week of zero wear-time, their data was treated as missing. Initial analysis were conducted using a one-way repeated measures analysis of variance (RMANOVA) to examine the overall differences between the physical activity weekly means of each group: average daily *moves*, in-school *moves*, and out-of-school *moves*. Additional analyses were conducted using multivariate analysis of variance (MANOVA) to investigate whether the weekly means of each group differed across participant gender and ethnicity. A RMANOVA was utilized to determine changes in health-related fitness knowledge. All statistical significance was set to $p< 0.05$, and analyses were performed using IBM SPSS Statistics 23 for Windows®.

Out of the 40 students that returned their informed consent, 25 students (52% female, 48% male) had complete data for every week of the intervention and were used for data analysis. Average daily physical activity was their average number of *moves* across the three days. Average daily in-school physical activity was the participants *moves* between the hours of 7:00am-2:00pm averaged across the three days, and average daily out-of-school physical activity was the participants *moves* between the hours of 3:00pm-10:00pm averaged across the three days.

RESULTS

All data were normally distributed. The mean body mass index (BMI) was 19.8 kg/m^2 and the average BMI percentile was 55.5, suggesting the participating students on average were considered of normal or healthy weight (BMI < 84th percentile). Only 6 of the participating 25 children were considered overweight or obese (BMI > 85th percentile) (Centers for Disease Control and Prevention, 2015). The majority of participating children were White (56%), participant demographic information is provided in Table 1. It is also important to note that during baseline testing (Week 1) the average daily *moves* across all participants were 14,738.86(±2857.17), with 84% of participants accumulating over 12,000 *moves* per day.

The initial ANOVA examining average daily moves revealed a time main effect that was not significant (Wilks L=.718, $F_{(3,22)}$=2.86, p=.059, h^2=.282), despite a significant increase (p=.011) in health related fitness knowledge from pretest [M=62.2(±17.3)] to posttest [M=71.3(±16.1)]. The results suggested a significant difference (p=.007) in average daily *moves* between weeks 2 [(M=15868.8(±744.1)] and

Table 1: Demographic characteristics of participating children (n=25)

	n (%)
Sex	
Male	12 (48)
Female	13 (52)
Race	
Asian	4 (16)
African american	7 (28)
White (or non-Hispanic)	14 (56)
*Weight Status**	
Normal weight	19 (76)
Overweight	1 (04)
Obese	5 (20)

**Weight status was determined by BMI percentiles, which were classified according to the Centers for Disease Control (1) classification's age- and sex-specific BMI cutoff points for 'normal weight' (84th percentile and below), 'overweight' (85th to 94th percentile) and 'obese' (95th and above).*

3 [*M*=14073.8(±495.2)]. The ANOVAs conducted for in-school *moves* and out-of-school *moves* both suggested a time main effect of no significance (p=.119, p=.111, respectively). However, the results revealed a significant difference (p=.021) for in-school activity between weeks 2 [*M*= 9172.66(±376.5)] and 3 [*M*=8328.8(±250.8)], and a significant difference (p=.012) in out-of-school activity between weeks 2 [*M*=6802.8(±490.6)] and 3 [*M*=5819.3(±384.4)] (Figure 1).

Multivariate analysis revealed sex differences in average daily moves (p=.017), with males [*M*=16372.9(±733.3)] achieving significantly more *moves* than females [*M*=13724.2(±701.4)]. Similarly, sex differences were also found in out-of-school activity (p=.007), with males [*M*=7560.5(±519.2]) accumulating significantly more *moves* than females [*M*=5384.8(±496.5)]. There were no significant differences found in sex for in-school activity (p=.27).

When examining ethnic differences, there were no significant differences found across ethnicities for average daily moves or out-of-school activity. However in examining ethnic differences for in-school activity, our results indicated a significant difference (p=.019) between African American and Asian students, with Asian students [*M*=7879.6(±481.1)] getting significantly fewer *moves* than African American students [*M*=9439(±367.5)].

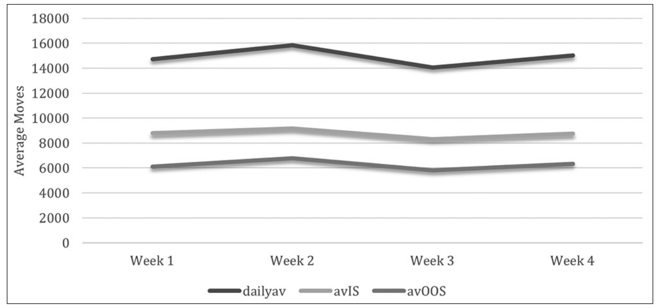

Figure 1: Average daily, in-school, and out-of-school moves

DISCUSSION

This study examined the effects of providing elementary students with a self-regulatory tool and information about physical activity and fitness on increasing their in- and out-of-school physical activity. Our results indicate that a wrist worn physical activity tracker, paired with a physical education unit targeting health-related fitness knowledge did not increase out-of-school physical activity. This could suggest that the implementation of a self-regulatory tool, such as an activity tracker, combined with physical activity information is not sufficient to motivate students to be more physically active throughout their day. Our findings are similar to a recent study examining 11-12 year olds that suggested an overall low engagement with the activity tracker, and engagement was dependent upon the support and encouragement of the research staff. Researchers found that during the few weeks that the research team visited infrequently or when the students were on spring break, the student's syncing of their devices dropped significantly. Their findings suggested that researcher presence and encouragement seemed to be a motivating factor for engagement in physical activity (Schaefer, Ching, Breen, & German, 2016). It is important to note that 84% of the participants were already meeting the 12,000 step/day recommendation at the onset of the intervention.

During week 1 (baseline), the activity trackers were sealed so that students were unable to monitor their physical activity. Beginning in week 2, the activity trackers were uncovered in order for the students to be able to self-monitor. Our analyses did reveal a significant difference between weeks 2 and 3 for average daily *moves* and in- and out-of-school *moves*. This finding could be indicative of reactivity to being able to monitor their physical activity. Reactivity is defined as a change in normal activity patterns when participants are aware of being monitored and could be a threat to the ability to accurately measure physical activity (Vincent & Pangrazi, 2002). Research studies examining reactivity among children and adults have been mixed (Scott, Morgan, Plotnikoff, Trost, & Lubans, 2014). Some research has suggested that reactivity seems to have larger effects on preschool-aged children compared to elementary-aged children and adolescents (Dössegger et al., 2014). Contrary to these findings, our results suggested that for this particular cohort of 10-12 year olds they did experience a reactive response to being monitored with the activity trackers that was not indicative of their habitual physical activity.

Our results also suggested gender differences for average daily *moves* and out-of-school *moves*. Males were getting significantly more activity outside of school, as well as overall physical activity. This finding coincides with existing literature suggesting that females engage in less physical activity and more sedentary time compared to their male counterparts (Troiano et al., 2008; Ridgers, Timperio, Crawford, & Salmon, 2013). When examining in-school activity, there were no gender differences suggesting that for this particular cohort there were equal opportunities to engage in physical activity throughout their school day. When investigating whether there were any ethnic differences, no differences were found for average daily *moves* or out-of-school activity. However, there were significant ethnic differences found for in-school activity. Our results suggested that Asian students were getting significantly less physical activity during the school day compared to African American children. A 5-year longitudinal study suggested that Asian females (ages 12-16) showed a faster increase in sedentary behavior compared to White females the same age, and African American females engaged in significantly less physical activity compared to White females. However, there was no significant differences reported between Asian and African American children's physical activity or sedentary behavior (Brodersen, Steptoe, Boniface, & Wardle, 2007). The findings from our study and other's underline the importance of ensuring that there are culturally relevant opportunities for physical activity within schools.

Over the course of the intervention, students health-related fitness knowledge did increase significantly. This increase in knowledge did not seem to have an effect on the participant's total daily, in school, or out-of-school physical activity levels. Although contrary to other studies suggesting that increasing physical activity knowledge through in-school instruction could increase out-of-school physical activity levels (Chen, Kim, & Gao, 2014; Sirota et al., 2014), our findings suggested no change in their physical activity levels. It is important to note, that the majority of participants were already meeting step count recommendations prior to the intervention. This could have an effect on their ability to significantly increase their physical activity, despite their increase in health-related fitness knowledge.

CONCLUSIONS

This study demonstrated that the use of activity trackers and information alone could not be sufficient in improving physical activity levels among 5th graders. Although the student's health-related fitness knowledge increased, this was not found to have an effect on their physical activity levels. Our results also indicated an initial rise in physical activity during the first week of the intervention; this is thought to be a reactive response to being monitored and not indicative of an increase in the student's habitual physical activity levels. With the increasing availability of activity trackers, it is becoming easier to use and implement these monitors into physical activity interventions as a means of self-monitoring. However, it is important to remember that within Bandura's social cognitive theory, self-regulation involves three principles including: self-monitoring of one's behavior, judgment of one's behavior in relation to personal and environmental standards and expectations, and self-reaction to one's behaviors (Bandura, 1991). Activity trackers offer the ability to self-monitor, but cannot offer internal psychological processes such as judgment in comparison to personal and environmental standards and self-reaction. Similarly, activity trackers are offering a means of external motivation for physical activity. Research has suggested that for a change in habitual physical activity one must achieve intrinsic motivation for a behavior (Teixeira, Carraca, Markland, Silva, & Ryan, 2012). In future interventions incorporating the use of an activity tracker as a self-regulatory tool, it may be advantageous to include psychological components to help improve habitual physical activity.

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