

Enhancing the Fitness and Academics of Children using Technology in the Schools (FACTS)

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Abstract:

The purpose of this study was to evaluate the effects of activity trackers on student activity levels during elementary Physical Education (PE) and a school day. One hundred sixty 4th-grade students from rural schools wore the Fitbit Charge HR and/or the New-Lifestyles Digi-Walker SW-200 during randomly assigned conditions. Four main conditions for feedback included: (1) Fitbit and Digi-Walker (N= 17); (2) Fitbit only (N=11); (3) Digi-Walker only (N= 15); and (4) control group (N=21). Feedback, equipment, and quiz data were analyzed using a two-way ANCOVA. A MANCOVA was used for the rurality data. An independent t-test was used for gender vs time of day and a dependent t-test for PE participation. Regarding feedback, condition (3) had significantly more steps than conditions (1) and (2) ($F = 7.266$, $p = 0.001$). For equipment sharing, the mass group had significantly more steps than the distributed group ($F = 9.717$, $p = 0.001$). Quiz data revealed the treatment group had significantly higher scores than the control group ($F = 6.37$, $p = 0.16$). No significant difference between rurality groups at pre-test ($F = .139$, $p = 0.711$) or post-test ($F = .548$, $p = 0.462$) was found. For gender vs time of day, males had significantly more average steps than females during PE ($t = 3.18$, $p = 0.004$) and recess ($t = 3.13$, $p = 0.005$), but not during other times of the school day ($t = 1.911$, $p = 0.065$). For PE participation, PE days had a significantly higher number of steps than non-PE days ($t = 6.609$, $p = 0.001$).

Key Words: activity tracker, physical education, physical activity, elementary school

Introduction

Activity trackers are electronic devices that help to track a person's physical activity levels, and if advanced enough, even their physiological responses such as heart rate, sleep activity, and so on. Examples of popular activity trackers are Fitbit, Google Watch, Apple Watch, and Jawbone. The use of activity trackers has increased now that these devices are readily available for the public to use at a decent price. Not only that, but people are also more conscious about their health these days and wish to have a way to track their daily activities. However, a question that commonly arises is whether children use activity trackers. And if so, does it affect their physical activity levels? Research indicates the most common reason children use activity trackers is to track and study their daily physical activity levels (Lee et al., 2015; Müller et al., 2018; Pittman, 2020). In addition, teachers use activity trackers to help children learn how to interpret data, statistics, and physical activity in general (Lee et al., 2015). With many school programs and research projects taking place in school settings, the importance and use of activity trackers with children have increased significantly over the years. Müller et al. (2018) suggested that wearable physical activity trackers may be easy and convenient devices to use for physical activity assessment in young children. However, this study has yet to determine or clarify if wearing a physical activity tracker has the potential to increase physical activity levels for primary and secondary cardiovascular disease prevention and long-term compliance.

Pittman (2020) compared not only the effect of activity trackers but also a companion social website and text messaging interventions on body mass index (BMI), body fat percentage, physical fitness, and physical activity self-efficacy of children. Unlike the previous study, Pittman shows that activity trackers help increase physical activity levels in children. Interestingly, the researchers found that the activity tracker group in the study had an increase in body fat percentage and BMI, even though there was a significant increase in fitness. These findings are uncommon as activity tracker interventions normally help promote physical activity levels in all age groups. So, are activity trackers beneficial to children to track their physical activity levels and would this make a difference? With this in mind, the current study set out to use Fitbits in elementary physical schools to address several questions. Here are the questions we addressed:

1. What are the effects of different types of feedback using activity trackers on activity level?
2. What is the most effective method, consecutive days vs. once a week, of sharing equipment for tracking elementary students' activity?
3. Does student analysis of activity data impact performance on the State Standards Enhancing the FACTS Evaluation?

4. What impact does the use of technology for activity tracking have on students' activity levels based on rurality?
5. How do activity levels differ between boys and girls during physical education, recess, and other times of the school day?
6. To what extent does participation in physical education increase children's physical activity levels during the school day?

Methods:

Participants

Institutional Review Board approved this study. A total of 160 4th-grade students from 1 very-rural and 2 rural elementary schools in Arkansas participated. We obtained parental or guardian consent for all participants before the study.

Equipment

The study relied on the Fitbit Charge HR and the New-Lifestyles Digi-Walker SW-200 activity tracker. We measured the participants' wrists to determine the size of Fitbit Charge HR that best fit their wrist. However, the fit was not overly important as heart rate data was not collected or analyzed in this study. At the time of data collection for this study, Fitbit did not make an activity tracker for children; however, Jackson et al. (2019) determined the Fitbit Charge HR as an appropriate activity tracker for children.

Feedback Question What are the effects of different types of feedback using activity trackers on activity level?

Participants.

Sixty-four fourth grade students ($n = 26$ males, $n = 38$ females) from a rural elementary school who received consent from their parent(s) or guardian(s) participated in this study.

Procedures.

We randomly assigned four classes of fourth graders to one of the following four conditions: ONE, the students wore the Fitbits and Digi-Walkers from 8:00 a.m. to 3:10 p.m. on the day they had physical education and monitored their steps throughout the day by looking at their activity trackers ($N = 17$); TWO, same as ONE except students wore only the Fitbits ($N = 11$); THREE, same as TWO except students wore only the Digi-Walkers ($N = 15$); and FOUR, students did not wear activity trackers (control group) ($N = 21$). Before turning in their activity trackers at the end of the day, students in the three treatment groups recorded and charted their steps. Students in the treatment groups also received slips of paper with the date, a fitness fact, and space for them to write how many steps they got that day to take home. Before beginning eight weeks of participating in one of the four conditions, students participated in pre-test step data collection by wearing Digi-Walkers taped shut. We gathered the taped Digi-Walkers at the end of the school day and used this data as the covariant and repeated this process during the eighth week for the post-test.

Analysis/Results.

At the end of eight weeks, a Two-way (gender x condition) Analysis of Covariance (ANCOVA) was applied to the post-test step data (covary on pre-test step data) using the SPSS statistical package.

We ran Levene's test and normality checks and all assumptions were met. The adjusted means of the number of steps taken for males and females were 6207.42 ± 375.858 and 5026.49 ± 313.734 , respectively and under Conditions ONE, TWO, THREE, and FOUR, 4307.73 ± 1549.70 , 4668.09 ± 1981.15 , 7393.72 ± 1910.42 , and 6098.28 ± 2043.61 , respectively. The results of the ANCOVA found a significant difference between males and females ($F = 5.802$, $p = .019$) and among the groups ($F = 7.266$, $p = .001$). Post Hoc tests revealed students in Condition THREE/Digi-Walker had significantly more steps than those in Conditions ONE/Fitbit and Digi-Walker ($p = .001$) and TWO/Fitbit ($p = .006$). There were no significant differences between the number of steps in Condition Four/Control and the three treatment groups. Figure 1 illustrates the similarities and differences between groups.

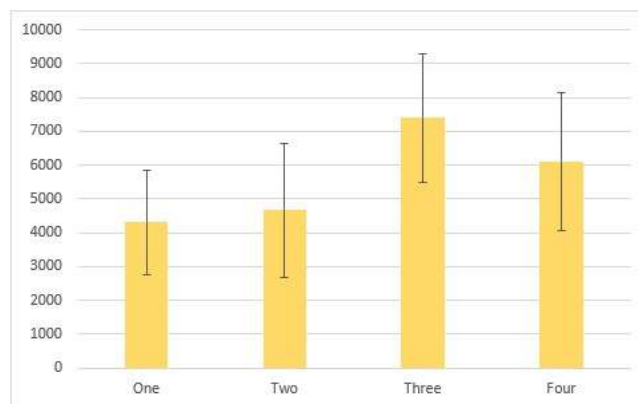


Figure 1: Feedback Question: Mean Number of Steps

* Significant at < 0.05 level.

Conclusions.

Males had significantly more steps than females. Students using Digi-Walkers for feedback during the school day have significantly more steps than those using Fitbits plus Digi-Walkers or Fitbits alone. Students in groups using activity trackers for feedback do not significantly differ in their number of steps from students in the control group. The current study contrasted with a study by Zerger et al. (2017) which found that feedback in general improved activity levels. In contrast, our findings also differed from Godino et al. who found that the type of feedback failed to significantly impact physical activity levels (2013). Surprisingly in the current study, only the Digi-Walker pedometer feedback resulted in greater physical activity than the control condition which had no feedback. While this agrees with the study by Van Hoyer et al. (2018) conducted among adults, researchers need to look more into this area.

Equipment Sharing Question

What is the most effective method, consecutive days vs once a week, of sharing equipment for tracking elementary students' activity?

Participants.

Thirty-five fourth-grade students from a rural elementary school who received consent from their parent(s) or guardian(s) participated in this study.

Procedures.

We randomly assigned two classes to either Distributed or Mass Groups. Students in both groups wore Fitbit Charge HR and New-Lifestyles Digi-Walker SW-200 activity trackers to monitor their physical activity for a total of eight days. Students in the Distributed Group ($n = 17$, males = 7, females = 10) wore the Fitbits and Digi-Walkers from 8:00 a.m. to 3:10 p.m. once a week for eight weeks. Students recorded and charted their steps at the end of each of the eight sessions. Students in the Mass Group ($n = 18$, males = 7, females = 11) followed the same protocol as the Distributed Group except wore the activity trackers for eight consecutive school days. Before participating in either condition, we gathered pre-test step data by having students wear Digi-Walkers taped shut. At the end of the school day of the pre-test, we gathered the taped Digi-Walkers, used this data as the covariant, and repeated this process during the eight sessions in both conditions for the post-test.

Analysis/Results.

An Analysis of Covariance (ANCOVA) was applied to the post-test step data gathered from the taped Digi-Walkers (covary on pre-test step data) using the SPSS statistical package.

We ran Levene's test and normality checks and all assumptions were met. The means of the number of steps taken for the Distributed and Mass Groups were 4417.47 ± 1603.88 and 6713.22 ± 2515.14 , respectively. The results of the ANCOVA found students in the Mass Group had significantly more steps than in the Distributed Group ($F = 9.717$, $p = .001$). See Figure 2.

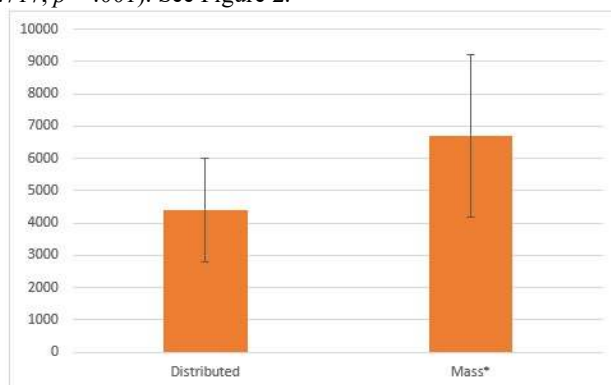


Figure II: Equipment Sharing Question: Mean Number of Steps

* Significant at < 0.001 level.

Conclusions.

Students wearing activity trackers and charting steps for eight consecutive school days (Mass) had significantly greater post-activity scores than students doing the same thing once a week for eight weeks (Distributed). Thus, students participating in a mass format of sharing equipment are more active than those participating in a distributed format and something schools should consider. Additionally, using the massed format with equipment such as activity trackers decreases the frequency of times the equipment changes hands, perhaps reducing the chances of spreading viruses, etc.

We did not find any other research addressing the effectiveness of various equipment-sharing strategies. Researchers should investigate further to verify whether or not this pattern holds. However, evidence from the current study suggests that a consecutive day (Mass) sharing strategy is more effective at increasing the activity levels of children than a once-a-week (Distributed) sharing strategy.

Data Analysis Question Does student analysis of activity data impact performance on the State Standards Enhance the FACTS Evaluation?

Participants.

Thirty-nine fourth-grade students ($n = 14$ males, $n = 25$ females) from a rural elementary school receiving consent from their parent(s) or guardian(s) participated in this study.

Procedures.

We randomly assigned two classes of fourth graders to either treatment ($n = 15$ total, males = 6, females = 9) or control ($n = 24$ total, males = 8, females = 16) groups. The students in the treatment group wore the Fitbits and Digi-Walkers from 8:00 a.m. to 3:10 p.m. one day a week they had physical education and monitored their steps throughout the day by looking at them. At the end of the school day, these students charted their Fitbit and Digi-Walker steps using a bar graph format for the first four weeks and a line graph format for the second four weeks. Students in the control group did not chart steps or wear activity trackers during the eight weeks.

Students in the treatment group recorded and charted their Fitbit and pedometer steps in their classroom at the end of the school day. Students also wrote their steps down on a slip of paper that included a different fitness fact each week to take home. The week of the pre-test, all students took a 10-point quiz over selected State Standards. At the end of eight weeks, the students took the quiz again.

Analysis/Results.

A Two-way (gender x condition) Analysis of Covariance (ANCOVA) was applied to the quiz data (covarying on pretest scores) to determine if using the activity trackers and charting step data significantly affected post-test quiz scores regarding gender or condition.

Levene's test and normality checks were carried out and the assumptions met. The adjusted means of the quiz scores for the treatment and control groups were 8.23 ± 1.61 (boys = 8.01 ± 1.56 , girls = 8.44 ± 1.61) and 6.87 ± 1.65 (boys = 6.86 ± 1.58 , girls = 6.88 ± 1.63), respectively. The results of the ANCOVA found no significant difference between boys' and girls' scores ($F = .181$, $p = .67$.); however, quiz scores from the treatment group were significantly higher than those of the control group ($F = 6.37$, $p = .016$). There was no interaction effect between gender and condition ($F = 0.136$, $p = 0.714$). Figure 3 shows the differences between groups.

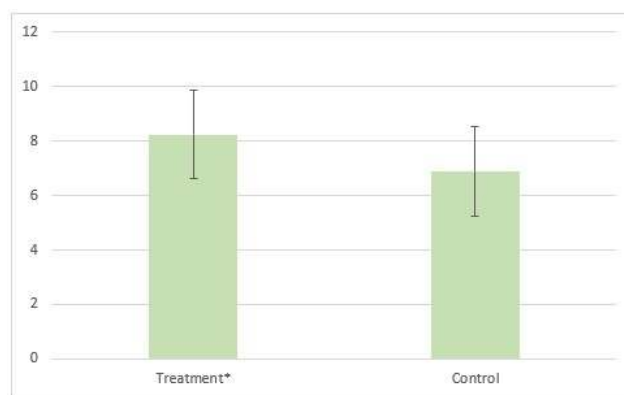


Figure III: Data Analysis Question: Mean Number of Steps

* Significant at < 0.05 level.

Conclusions.

Students using activity trackers to monitor and chart activity during the school day perform significantly higher on tests covering selected computer science and physical education state standards than students in the control group. Analyzing data collected from activity trackers did not impact the results of girls' and boys' test scores differently. Additionally, the lack of interaction effect means that there were similar responses from boys and girls during both conditions.

The current study seems to be the first of its kind. More research may be necessary to determine whether or not this is a consistent effect. We are unsure whether or not the effect relates to the analysis of physical activity or the specific use of a tool, such as the activity trackers; however, it seems likely that the analysis is responsible for the change in scores. Investigators need to conduct additional research to ascertain the particular contributions to improved test scores.

Rurality Question

What impact does the use of technology for activity tracking have on students' activity levels based on rurality?

Participants.

Fifty-six fourth graders from two elementary schools (rural and very-rural), whose parent(s) and/or guardian(s) signed consent forms, participated in the study. All students were from the same school district but different towns. The population of the rural town was 29,318 and from the very-rural town was 1,051.

Procedures.

Students at both schools received the same physical education lessons once a week for 60 minutes from the same certified physical education teacher who taught Mondays and Wednesdays at the very-rural school and

Thursdays and Fridays at the rural school. All students wore Fitbit Charge HR and Lifestyle SW-200 Digi-Walker activity trackers on the school day they had physical education for eight weeks and charted and recorded their steps when they turned in their trackers.

Analysis/Results.

Data passed Levene's test for equality of variances. We calculated a MANOVA to determine the effect of school rurality on pre-test and post-test scores using the SPSS program. The mean steps of the students from the rural ($n = 31$, males = 15, females = 16) and very-rural ($n = 26$, males = 10, females = 16) were pre-test 6253.29 ± 295.94 and 6088.44 ± 329.55 and post-test 5929.97 ± 286.96 and 5611.92 ± 319.54 , respectively. The results of the analysis found no significant difference in any test scores (pre-test $F = .139$, $p = .711$; post-test $F = .548$, $p = .462$).

Conclusions.

Using technology such as activity trackers does not significantly impact the activity level of rural and very-rural students differently. Current research has shown a difference in activity levels between urban and rural children but has not addressed the impact of the use of technology on activity levels (Befort et al., 2012; Lui et al., 2008; Joens-Matre et al., 2008; Manyanga et al., 2020). We found both schools included in the current study would be considered rural according to existing research. As such, the differences between the rurality of the two schools may be too small to affect a change in the activity levels of their students that might have been induced by the use of technology. Otherwise, technology tools, such as activity trackers, have little impact on the activity levels of rural and very-rural children.

Gender vs. Time of Day Question

How do activity levels differ between boys and girls during physical education, recess, and other times of the school day?

Participants.

The parent(s) or guardian(s) of the subjects (males = 13, females = 25) gave consent before they participated.

Procedures.

Boys ($n = 13$) and girls ($n = 25$) from two fourth-grade classes at the same rural school wore Fitbit Charge HR activity trackers from 8:00 to 3:10 once a week for eight weeks on the days they had physical education. We downloaded the Fitbits and collected the number of steps taken during physical education, recess, and other times (i.e., classroom, between classes, lunch, etc.) using the Fitbit Software Program.

Analysis/Results.

We applied three independent t-tests to the step data comparing boys' and girls' steps during physical education, recess, and other times. Additionally, we used the Bonferroni adjusted alpha of .016 to account for the inflation of alpha with multiple tests. Results indicated that boys had significantly more average steps than girls during physical education (boys = 1969.30 ± 447.40 , girls = 1493.43 ± 422.42 ; $t = 3.18$, $p = .004$) and recess (boys = 1429.75 ± 440.16 , girls = 1071.96 ± 302.06 ; $t = 3.13$, $p = .005$). However, there was no significant difference between the average number of steps taken by boys and girls at other times during the school day (boys = 3359.33 ± 625.13 , girls = 3015.4 ± 592.20 ; $t = 1.911$, $p = .065$). Figure 4 shows the number of steps taken by time of day.

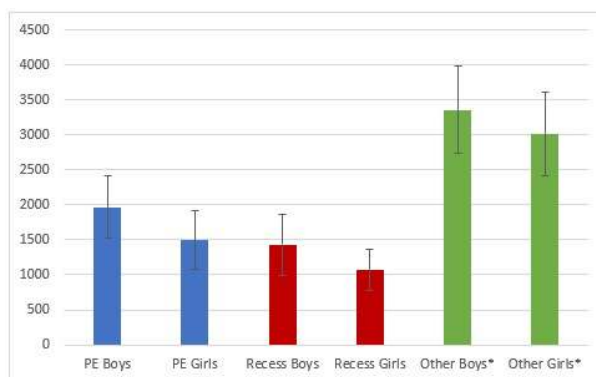


Figure IV: Gender vs Time of Day Question: Mean Number of Steps

* Significant at ≤ 0.05 level.

Conclusions.

Boys have significantly more ($p < .05$) steps than girls during physical education and recess but not at other times during the school day ($p > 0.05$). This agrees with the findings from the feedback question, which also showed that boys took more steps than girls. Additionally, this agrees with existing research, although none of those studies addressed the time of day (Denton et al., 2013; Dupuy et al., 2011; Llorente-Cantarero et al., 2012; Mayo, et al., 2020). Because the current study only addressed the school day, we cannot compare it to Reimers et al, (2019) which found that primary school boys are more likely to participate in sports outside of school.

PE Participation Question

To what extent does participation in physical education increase children's physical activity levels during the school day?

Participants.

Twenty-five fourth-grade students from a rural elementary school who received consent from their parent(s) or guardian(s) participated in this study.

Procedures.

Students wore Fitbit Charge HR activity trackers to monitor their physical activity every school day from 8:00 a.m. to 3:10 p.m. for eight consecutive days over the course of two weeks. Students had physical education once each week for 50 minutes. We collected step data from the Fitbits on the two days preceding the days the students had physical education and then again on the two days they had physical education. One student was absent on the day he had physical education; therefore, we had forty-nine paired samples of step data on days with and without physical education.

Analysis/Results.

We applied the forty-nine paired samples to a dependent t-test using the SPSS statistical package. The results of the t-test found that the number of steps students took on days with physical education ($\bar{x} = 6451.29 \pm 1753.21$) was significantly higher ($t = 6.609$, $p = .001$) than on days without physical education ($\bar{x} = 5012.65 \pm 1633.55$). See Figure 5.

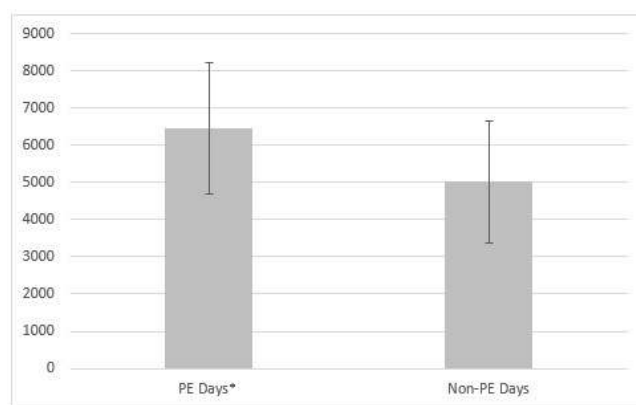


Figure V: PE Participation Question: Mean Number of Steps

* Significant at 0.001 level.

Conclusions.

Participation in physical education increased the number of steps, hence, the physical activity levels of children in the study. The results from this study were similar to that shown in Ryu et al.'s (2020) study, whereby students who participated in physical education were 1.88 times more likely to meet the physical activity guidelines compared to those who did not participate in physical education. Uddin et al. (2020) found similar results whereby physical education participation was positively associated with physical activity in adolescents. Active transport may have played a role in physical education participation because the travel between destinations via walking, cycling, or other motorized methods would require them to already be physically active when commuting to and from school (Duncan et al., 2015). Physical education participation may also have increased physical activity levels in children because of self-efficacy, types of motivation involved (i.e., amotivation, external motivation, internal motivation), teacher autonomy support, and physical activity enjoyment (Hernández et al., 2019; Lodewyk et al., 2009; Shen, 2015; Shen et al., 2010; Woods et al., 2012). Shen et al. (2012) found that unfavorable attitudes and lack of perceived support determined whether or not students participated in physical education. The current study agrees with existing research that physical education improves the physical activity of children.

Discussion and Conclusions

In conclusion, elementary school children successfully used Fitbits to enhance their physical activity levels as well as academic performance. We set out to address 6 different research questions and found several unique and potentially beneficial results.

1. What are the effects of different types of feedback using activity trackers on activity level?

First, the type of feedback may impact physical activity levels. However, school districts that cannot afford Fitbits need not worry as the cheaper pedometers garnered better results. We need to conduct more research to better understand the impact of types of feedback on physical activity levels among elementary school children.

2. What is the most effective method, consecutive days vs. once a week, of sharing equipment for tracking elementary students' activity?

The current study definitively showed that sharing equipment in a consecutive day fashion resulted in higher activity levels. Physical education teachers who are trying to maximize their equipment use and efficiency by

sharing it among classes may want to follow the consecutive days pattern rather than sharing such equipment in a distributed pattern, such as once a week, to optimize students' activity levels. Future research could determine whether or not sharing on a distributed pattern of multiple days per week, such as Monday/Wednesday or Tuesday/Thursday, also improved activity levels.

3. Does student analysis of activity data impact performance on the State Standards Enhancing the FACTS Evaluation?

Student test scores improved after analyzing data from wearing activity trackers. Teachers desiring to combine academics and physical activity components may find this aspect of the study insightful. Students who used data from their own physical activity performed better on academic tasks later. The application of this study may have far-reaching implications.

4. What impact does the use of technology for activity tracking have on students' activity levels based on rurality?

The current study evaluated a rural and a very-rural school. Most research compares urban and rural schools. Our study found no differences in activity levels between students in rural and very-rural schools. While existing research indicates that there are differences based on population density (Befort et al., 2012; Lui et al., 2008; Joens-Matre et al., 2008), both schools evaluated here would likely be included in the rural category when compared to that research. It is also likely the students from the two schools had too similar backgrounds for the treatment to impact them differently.

The current study was primarily evaluating whether or not the use of technology impacted activity levels differently based on rurality. Researchers have not looked at this aspect of the study previously. We recommend future research on this topic investigating rural versus urban schools as the current study found no differences. Thus, it seems that physical educators should use technology tools if students are excited about them and their district can afford them and not worry about employing them if this is not the case.

5. How do activity levels differ between boys and girls during physical education, recess, and other times of the school day?

Boys were more active than girls during physical education class and recess. The current study did not evaluate the reasons behind this. However, Reimer et al. (2019) found that differences in the perceived level of social support received from both peers and parents played a role in the decreased activity levels of girls. Efforts to improve the activity levels of girls may need to look beyond the specific activities of the individuals and look to role models and other forms of social support that may encourage girls that physical activity is acceptable and encouraged.

6. To what extent does participation in physical education increase children's physical activity levels during the school day?

Our data provide an argument for maintaining physical education in schools. Budget cuts have led to a reduction of physical education programs in many states in the United States of America, which in turn have exacerbated the obesity epidemic (Slade, 2020). With the increasing childhood obesity epidemic, the ability to increase activity levels becomes more and more important. Physical activity levels in the current study were significantly higher on days that students participated in physical education classes. While the study only evaluated a single class of elementary school children in a rural community, this data is a starting point for a broader justification of physical education. This does agree with research by Ryu et al. (2020) and Uddin et al. (2020). Physical education professionals need to conduct additional research to determine whether the findings of this study hold on a broader scale. If they do, this could have far-reaching implications for the health of our children while justifying the funding of physical education programs.

In general, elementary students using technology in the form of activity trackers has several interesting implications for use in elementary schools. One practical application from the study relates to equipment sharing, as activity levels were highest with a consecutive-day strategy for sharing equipment between classes. Next, students' analysis of data improves performance on academic assessments. Tying the physical activity class and the regular classroom together may be a way to improve the academic performance of students. Additionally, boys were more active than girls at recess and in physical education; although, current research suggests that better role models and social support may help. Physical educators may consider this in their classrooms. Finally, our evaluation of technology in physical education revealed that students have improved physical activity on days when students had physical education classes. Perhaps this data can spur a larger discussion about the need for funding for physical education in public schools.

Conflicts of interest - There are no conflicts of interest to disclose.

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