Decreasing Sedentary Behaviours in Pre-adolescents using Casual Exergames at School

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ABSTRACT

There are risks to too much sedentary behaviour, regardless of a person's level of physical activity, particularly for children. As exercise habits instilled during childhood are strong predictors of healthy lifestyles later in life, it is important that schools break up long sedentary periods with short periods of physical activity. Casual exergames are an appealing option for schools who wish to engage adolescents, and have been shown to provide exertion levels at recommended values, even when played for only 10 minutes. In this paper we describe a preliminary survey with teachers of a local school that informed the deployment of a casual exergame with a group of pre-adolescent students from the same school. We show that students preferred the game to traditional exercise, that the game was able to generate appropriate levels of exertion in pre-adolescents, and that students have a sophisticated understanding of the role of exercise in their lives. Overall, we establish the feasibility of casual exergames for combating sedentary behavior in preteen classrooms.

Author Keywords

Exergames; school; children; physical activity; sedentary.

ACM Classification Keywords

K.8.0 [Personal Computing]: General - *Games*.

INTRODUCTION

Recent work among health researchers has shown that alongside the variety of physical, cognitive, and emotional benefits provided by regular physical activity, there are also negative consequences associated with sedentary behaviour [33]. Interestingly, these consequences are distinct from those that result from a lack of physical activity [33]. Although it may seem surprising, physically-active people who exercise each day (e.g., biking to work) can also be at risk from sedentary behaviour if the remainder of their time is spent in sedentary activities (e.g., sitting at a desk) [22]. The potential health outcomes are of particular relevance to information workers who spend large amounts of time working on computers, and schoolchildren, who spend many hours a day sitting at their desks, and many groups are now exploring the need for anti-sedentary guidelines to exist alongside guidelines for physical activity [34].

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Although parents and recreation workers can help children receive the recommended levels of physical activity [34] in the mornings or after school, schools themselves are critical for preventing harmful sedentary behaviours during the day. Providing physical activity breaks for students is important. Younger children will often engage in spontaneous physical activity if given the opportunity; however, as children age, changing social dynamics often discourage physical activity during break times. This change in behavior tends to emerge during the 'tweens' when children are aged 9-13 [19, 28] and sedentary habits adopted during this critical period can have lifelong consequences [27]. While educators can encourage short bursts of physical activity throughout the day, these 'body breaks' can be difficult to administer to adolescents, who are not as thrilled by the vertigo of simply moving through space.

To encourage physical activity, researchers and developers have created a variety of exergames, by integrating exercise into the game mechanics (e.g., [18, 25, 37]). Moreover, casual exergames – computer games that players can learn easily and access quickly, using simple rules and special game mechanics, to motivate them to exercise at a moderate intensity for short periods of play [10] – are specifically designed to encourage small 'exerbreaks' throughout the day. Casual exergames could be used to decrease sedentary time amongst students by providing exercise experiences that are more compelling than traditional body breaks in a form that is socially acceptable to a tween audience, who have significant experience with computer games.

For a casual exergame to be deployed in a school setting, we feel that it should be acceptable to educators, enjoyable for students, provide sufficient – but not excessive – levels of physical activity, and not significantly interfere with students' workflow. In this paper we present the design and analysis of such a system.

We begin by conducting a series of semi-structured interviews with educators of 9-13 year olds at a local elementary school to identify the requirements of casual exergames that would make them useful in the classroom, to codify what has and has not worked in their classrooms in the past, and to understand the teachers' perceptions of the changing sedentary habits of their tween students. We then conducted a study of their students' responses to playing an existing and validated casual exergame, called GrabApple [10]. We compared physical activity levels and affective responses after students played GrabApple, a sedentary version of the game, and participated in a traditional body break led by a physical education instructor. Students also provided answers to surveys about their attitude to exercise and sedentary behavior before and after the experiment. Finally, students and teachers returned several months later to evaluate how the students' attitudes towards exercise had changed with the passage of time. The interviews were meant to establish the acceptability of exergames in the classroom, and the experiment to confirm the game's ability to engage students and provide appropriate levels of activity, satisfying our four goals.

Our results showed that casual exergames could be a promising method for combatting sedentary behavior in schools amongst tween populations. Students found the game more engaging than traditional exercise and were better able to maintain a target activity intensity. In addition, the game required little supervision and motivated target levels of physical activity through the game mechanics, alleviating the burden on teachers who are already overextended. Combined, the qualitative and quantitative results obtained through our research provide support for the future design and deployment of casual exergames in for use by schoolchildren.

RELATED WORK

The goal of our research is to consider the introduction of efficacious casual exergames into the classroom. As such, we cover literature on the general benefits of exercise, children's and adolescents' attitudes towards exercise, and related literature on exergames including casual exergames.

Physical Activity during Childhood and Adolescence

Regular physical activity is crucial during childhood and adolescence, as it has a large impact on an individual's ability of maintaining a healthy lifestyle during adulthood [27]. The National Association for Sport and Physical Education (NAPSPE) recommends that children engage in more than 60 minutes of moderate to vigorous exercise a day. Exercise can be carried out in multiple short bouts lasting at least 15 minutes, including rest and recovery time [6]. However, only about half of US children meet the exercise recommendations on five or more days per week [39]. Physical exercise can help prevent chronic disease, reduce the cholesterol ratio, increase bone density [30] and reduce obesity [8] in children. It has been shown that fitness through physical activity can also enhance measures of children's psychological well-being, such as self-satisfaction and self-esteem [30], and has been shown to improve mood [20]. Finally, short bursts of exercise can result in acute (i.e., short and temporary) cognitive benefits, including improvements on the Working Memory Task [26], the Rey Auditory-Verbal Learning Test [24], which measures recall, and the Stroop test [20,38], which executive functioning.

While the research community has primarily focused on the positive effects of physical activity, it has recently been suggested that there may not only be benefits of being physically active, but also distinct negative effects caused by sedentary lifestyles [11, 33]. For instance, sedentary people might experience differences in carbohydrate metabolism [4] and vascular health [15]. This suggests that the effects of generally sedentary lifestyles are different than those caused by a lack of intense physical activity [16, 23], and that people who regularly engage in exercise may still be at risk of negative effects of if they are mostly sedentary during the day, e.g., while working an office job or attending school. In response to these findings, different organizations that previously focused on guidelines for physical activity have recently released anti-sedentary guidelines that specifically encourage activity throughout the day, for example, the Canadian Society of Exercise Physiologists has published guidelines that address sedentary lifestyles among adolescents [34].

The games research community needs to re-think the way it approaches games as an intervention for encouraging healthier lifestyles. If intense physical activity as currently provided by many exergames is not sufficient to address activity-related health issues among children and teenagers, new game concepts should explore the integration of short bursts of activity throughout the day to counteract negative implications of extended periods of inactivity [22].

Attitudes about Physical Activity

Related work reports a decline in children's participation in physical activity in early adolescence [19, 28]. One of the important predictors of people engaging in physical activity is attitude towards exercise [7]; in particular children will participate in physical activities when they have a positive attitude towards physical activity [14]. Several studies have shown that integrating health education in classes, labs and readings can have positive impact on children's health attitude [5, 12]. However, many schools (particularly in the U.S.) intend to improve students' academic scores by increasing time for core curricular subjects and decreasing physical education (PE) [36], or other scheduled physical activity. Therefore, it is challenging for schools to allocate more time for physical activity during the school day [3].

Casual Exergames

Casual exergames are based on the insight that the daily amount of exercise necessary to obtain health benefits can be broken down into smaller chunks, while maintaining the positive effects [6, 17]. To help people add these small chunks of physical activity throughout the day, casual exergames [10] apply the principles of casual game design to the design of exergames: most importantly, they allow players to engage in physical activity in short bouts. Specifically, casual exergames are defined as *computer games that players can learn easily and access quickly, using simple rules and game mechanics, to motivate them to exercise at a moderate intensity for short periods of play* [10]. Research on casual exergames has shown that as little as ten minutes of casual exergame play can produce moderate-intensity exertion levels, improving players' affective states and providing significant levels of acute cognitive benefits compared to sedentary casual games [9] (i.e., can improve post-play ability of players to focus attention). While these results are promising, prior work has only explored the benefits of casual exergames with adults in lab settings. This paper expands on the approach by introducing casual exergames in a classroom setting, investigating whether benefits still exist when casual exergames are applied in a less controlled environment.

Exergames in Schools

Lwin and Malik [21] argue that incorporating exergaming into PE lessons is more beneficial than regular physical education (PE) as it can improve physical activity beliefs and behaviors. However, Sun [32] claims that incorporating exergames into PE may not produce health benefits, as some commercial exergames may not provide appropriate levels of physical activity. Beyond applying commercially available games in schools, researchers have introduced exergames using mobile phones to help students at school to fight sedentary lifestyles [18, 25, 37], and the PlayFit project aims to persuade teenagers through playful interventions and ambient interaction based on four design principles []. Although results suggest that these games can motivate students to become more active in the short term, instrumenting each user with body-mounted sensors is complex, which might create challenges in deploying such games in schools.

EXPERIMENTS

We conducted an experiment to examine how casual exergames can be deployed in school settings. Our experiment proceeded through three phases. First, we deployed a survey to Grade 7 teachers from a local school to understand their perception of casual exergames as a classroom activity, student attitudes and the appropriateness of technology. Second, we conducted a single day study with the Grade 7 class from the same school, collecting quantitative and qualitative data. Finally, we administered a follow-up questionnaire five months later to determine how student perceptions of exercise and exergames had changed over time. We describe each of these in turn.

TEACHERS' PERCEPTION OF EXERGAMES

We invited four grade seven teachers (three men) responsible for the students' program to provide insights into their students' attitudes towards physical activity. Two taught physical education (in addition to other subjects) and one taught dance in addition to other subjects. Their previous teaching experience spanned from kindergarten to grade eight. We provide a summary of the responses to the semi-structured interviews according to the topic.

Age-Related Changes in Physical Activity

All of the teachers pointed out that students become less active when they grow older. "*Students seem more apathetic toward teacher directed/organized activity. They want to be in charge of their own activity; however, unfortunately they still need guidance and motivation",* and that they are less motivated to exercise: *"less motivated, less interested in getting sweaty, less interested in working hard, slower",* "*They move less and stop running places. They used to run just because they wanted to get to places as fast as possible. When they get older they slow down and tend to only move fast when playing a game. The worst thing is they seem to require organized sport to motivate them to play hard."* All teachers noticed older students are more sedentary than younger students. They also provided possible explanations for this change: *"longer classes, we expect older ones to sit and work longer - attention span longer*", "*Body changes, less time because many will start a part time job, more homework in high school, friends".*

Two teachers mentioned that students start to worry about their image, pointing out how *"they become more social and worry about image"*, and that *"other things become more important to them, image!!!!*" Two teachers suggested that girls are more concerned about their image and avoid physical activity: *"They would be just as content to do nothing for fear of how they will be viewed by their peers. This is especially true for girls. I think they refrain from being physical as a result of how they might be perceived".*

Integration of Physical Activity in the Classroom

Three out of four teachers reported that they integrated physical activity into classroom activities, such as cardio, relays, combative, strength, stretch and dance. One teacher said s/he encouraged her/his students to try new activities every day and did body breaks twice a day. When asked whether they noticed whether or not students enjoyed the activities, teachers reported that most students liked it, but some were reluctant to participate. The teacher who frequently integrated physical activity into classrooms pointed out that his/her students "*loved when we counted and did certain jumping activities; they also loved stretching to quiet music*".

Three out of four teachers claimed positive effects of PE on their students, reporting that they are "*ready to learn, almost energized in a way that they are charged up*", "*when they really push hard and have fun they seem to come back to class relaxed with less behavioral problems", "I feel they are calmer after they have had a chance to burn off some steam".* Only one teacher who did not integrate any physical activities in classroom claimed that after PE, students are fidgety, and "*it is difficult to settle them back into the classroom setting"*.

Integration of Exergames in the Classroom

Three out four teachers stated that they would like to integrate exergames in the classroom. Teachers expected benefits such as *"increased motivation towards getting physically active"* and *"increased focus"*. Furthermore, they saw advantages such as an *"increased heart rate, increased muscle memory,* and *motivation to score better than the last time"*. Teachers also noticed potential drawbacks of exergames, such as "*cheating, lack of motivation to those that are jocks*", and games being distractive, and a "*disruption of others*".

When asked how they would integrate casual exergames in the classroom, they came up with solutions such as "*setting up a station, whole class approach where one or 2 or 6 people are active and rest of class is holding a pose while they are doing the challenge. Almost like a relay race*", *"probably as body breaks as the students see as necessary for their own personal wellness"* and "*might need to play it by ear but could set up a rotation or allow sign up to be used by those who enjoy it as a body break*".

When comparing casual exergames to regular exercise, teachers saw advantages of exergames, expecting them to "*increase confidence to those lacking skill in certain areas"*, pointing out that *"students will have more personal control and responsibility over their body breaks"*. Regarding students' attitudes towards exercise, teachers pointed out that they *"think it is something the students are more open to. It is an excellent way to disguise exercise"*.

These results show that the teachers who participated in our survey are generally open towards the integration of physical activity in the classroom. Their statements show that they are aware of benefits of activity, but that they also recognize potential problems, such as the disruption of other students if exercise units are not well-integrated into the schedule. Furthermore, the results underline the change in students' attitudes towards physical activity at the transition from childhood to adolescence, particularly highlighting the increasing sedentary habits among girls.

USER STUDY WITH ADOLESCENTS

To follow-up on the survey with teachers, we conducted an experiment on how casual exergames compare to sedentary games and traditional PE activities.

Participants

During the user study, 63 grade seven children (29 boys) from a local elementary school participated. Data from 3 participants were excluded (three children were unable to participate for the experiment's duration). Participants ranged from 11 to 13 years old (M=12). Seventeen of the participants reported that they played video games at least 5-6 days a week, six participants almost never played video games, and the majority of participants played 1-2 or 3-4 days per week. The majority of participants were familiar with games that require physical activity (e.g., Xbox Kinect, PlayStation Move and Nintendo Wii).

Our participants were physically active. When asked about exercise, 22 of the 63 participants reported engaging in daily physical activity outside of school, and only one participant almost never performed exercise outside of school. The remaining participants did exercise several days a week outside of school. In general, our participants were aware of the benefits of physical activity. At school, they participate in the *Healthy Bodies Active Minds* (HBAM) program, which provides extra PE classes and teaches students about nutrition and activity, and the physical and cognitive benefits of an active lifestyle.

The GrabApple Game

GrabApple (Figure 1) is a casual game that can be played in a 10-minute session. For a complete description, see [10]. The goal of the game is to pick up falling red and green apples and avoid touching the falling bombs using a virtual hand on the screen. In the exergame version of the game, the virtual hand is controlled through the movement of the player's body (sensed using a Microsoft Kinect), using the player's body weight as resistance to generate exercise, requiring jumping, ducking and movement. If players keep picking the same color of apple, a score multiplier that encourages additional movement is engaged. The hand can hold five apples. To empty the hand, players need to jump to the apple bag. In the sedentary version of the game, a mouse is used to control the virtual hand on the screen. We have previously used GrabApple in studies with young adults, and have shown that it is capable of producing moderate-intensity exercise [9,10].

Figure 1. Screenshot of the GrabApple game.

Experimental Conditions

Our study had three conditions. In the *exergame condition*, participants were asked to play the casual exergame GrabApple. In the *sedentary condition*, participants played GrabApple using the keyboard and mouse. In the *exercise condition*, participants performed traditional exercise (e.g. rope skipping, climbing stairs and running short distances while avoiding obstacles) guided by a PE teacher. In all three conditions, participants wore a heart rate monitor.

Procedure and Methods

The study methods and instruments were first approved by ethics offices at the University of Saskatchewan, Saskatoon, Canada, and the Saskatoon School District. All students and students' parents filled out informed consent and assent forms prior to arriving at the University campus. Students arrived at the university on the morning of a school day. Each student received an envelope with worksheets for recording their heart rate, surveys and a pencil. Students filled out demographic, exercise attitude, and affective state surveys. Finally, we divided the students into two groups: one group participated in the experiment in the morning, while the other group participated in the afternoon. When students were not participating in the experiment, they completed a half-day workshop on Scratch programming.

The experimental group began the experimental protocol watching a two-minute video explaining GrabApple. Afterwards, each participant put on a heart rate monitor (chest strap with wrist band display) with the help of their teachers and wrote down their resting heart rate on the worksheet. We divided the participants into three subgroups (8-12 students per group) and assigned each subgroup to a different condition (exergame, sedentary, exercise). The order of conditions was fully counterbalanced. Each group was accompanied by at least two teachers and three volunteers to supervise participants and administer the surveys. Participants in the exercise condition were in a separate room and guided by a PE teacher to ensure comparable levels of activity across groups. In each condition, participants performed one activity for ten minutes. After each condition, participants reported their heart rate on the worksheet and filled out the post-condition surveys, including questions of player experience, affective state, and the Borg Rating of Perceived Exertion (RPE) [1]. At the end of each condition, volunteers collected the surveys. When all groups from both sessions had finished all the conditions, students returned to the lecture theatre and filled out the post-experiment surveys.

After five months, the same group of children returned to the university for a follow-up survey and to learn about the results of the study. They then filled out another exercise attitude survey.

Measures

Exertion was measures through heart rate and the Borg Rating of Perceived Exertion (RPE) [1]. Player experience was collected through Likert scale questions about how fun, exciting, challenging, easy to learn, and frustrating the game was to play. To measure affective state, we used the Self-Assessment Manikin (SAM) scale [2], a pictorial 9-point scale that is commonly used to self-report affective states via valence (feelings of pleasure or displeasure) and arousal (activation of feeling).

Apparatus

We arranged two computer labs at a local university to run the experiment. Both the sedentary and exergame conditions were held in the same computer lab with 12 computers available for each condition. The game was played on a Windows PC with a 20-inch widescreen monitor. For the exergame condition, participants stood approximately 1.2m from the display.

Data Analyses

Although all participants engaged in all three experimental conditions, the time between each condition did not allow for heart rates to reliably return to resting levels. As such, we treated the data as a between-subjects experiment, using data from only the first condition played for the measures %maxHR and perceived exertion. A one-way ANOVA was conducted with condition as a factor (exergame, sedentary, exercise), and we used the Tukey HSD test for post-hoc measurements. Questionnaire responses (affective state, player experience, and attitude) were analyzed using the Friedman Test for multiple related samples.

Results

We present results for exertion, experience, affect, and attitude during the experiment.

Physical Exertion

The American College of Sports Medicine defines moderate-intensity exercise as 64-76% of maximum heart rate (maxHR=220-age) [35], vigorous-intensity exercise as 77-93% of maximum heart rate and very hard intensity exercise as greater than 94% of maximum heart rate. Figure 2 shows the average percentage of maximum heart rate (%maxHR) of the participants. While the values for the exergame condition are within the range of moderate to vigorous-intensity exercise, heart rates for the exercise condition are within the range of vigorous to very hard-intensity exercise. A one-way ANOVA showed that the differences in %maxHR were significant ($F_{2,56}$=150.2, p≈.000). Tukey's test showed that exercise intensity in the sedentary condition was significantly lower than intensity produced in the exergame condition (p≈.000) and exercise condition (p≈.000), and that the exergame condition was significantly lower than the exercise condition (p≈.000).

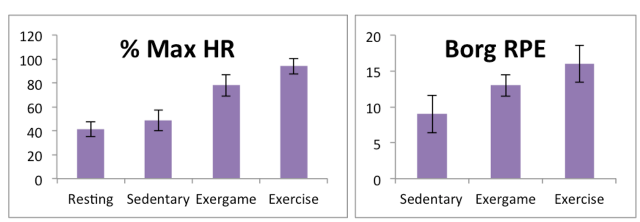

Figure 2. Means and SD for measures of exertion.

The results for Borg Ratings of Perceived Exertion (Borg RPE) are consistent with participants' heart rates. The exergame condition produced perceived exertion values within the recommended intensity: 12-13 (somewhat hard) to 15-16 (hard) [35]. The differences in perceived exertion between conditions were significant ($F_{2,53}$=44.9, p≈.000). Pairwise comparisons showed that the sedentary condition produced significantly lower levels of perceived exertion than the exergame (p≈.000) and traditional exercise (p≈.000), and that exergame was significantly lower than exercise condition (p=.001).

Our observations revealed that the PE teacher supervising the exercise condition pushed the students to give a lot of effort. She tailored the activities for individuals and offered encouragement and support, often participating with the students. This support is reflected in the exertion results and may not transfer to other environments with teachers who are not as committed to promoting physical activity.

From both a physiological and perceived exertion perspective, the exergame provided the appropriate amount of physical activity for an effective anti-sedentary body break. This result provides evidence that exergames can meet the physical requirements of a body break amongst our target tween demographic, our second requirement for establishing the utility of casual exergames as an antisedentary activity in the classroom.

Affective Benefits

Results for the effects of the different conditions on valence and arousal are displayed in Figure 3. Across all three conditions, results for valence were rather high, suggesting a positive mood among participants. A Friedman's Test for 3-related samples showed no significant difference in valence (χ^2_2=3.3, p=.195), but there was a significant difference in arousal (χ^2_2=34.3, p≈.000). Pairwise comparisons using Wilcoxon Signed Ranks Test revealed that players felt more aroused after the exercise condition than after the exergame condition (p=.001) or the sedentary condition (p≈.000), and more aroused after the exergame condition than the sedentary condition (p=.031). Although the SAM is designed to measure psychological arousal, it is likely that participants were also reflecting on the physiological arousal resulting from exercise intensity.

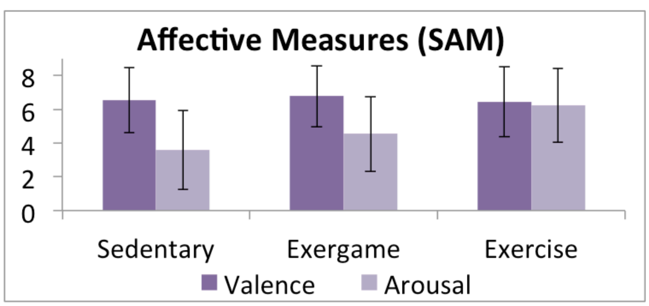

Figure 3. Means and SDs for valence and arousal as measured by SAM (1 is low, 9 is high).

Player Experience

We asked participants to rate six core aspects of the activities (fun, ease of learning, excitement, challenge, frustration, and whether they would consider playing it if they had a 10-minute break) on a 5-point Likert scale. The results show that participants' experience with the exergame and sedentary game as well as in the traditional exercise condition were generally positive. A Friedman test for 3-related samples showed significant differences in the ratings for challenge (χ^2_2=24.7, p≈.000) and ease of learning (χ^2_2=19.8, p≈.000) and marginally-significant differences for fun (χ^2_2=5.8, p=.055), excitement (χ^2_2=6.0, p=.051), and whether they would consider playing it (χ^2_2=5.7, p=.059). Pairwise comparisons using the Wilcoxon Signed Rank Test revealed that participants rated the exergame condition as significantly more fun than the exercise condition (p=.045) and would consider playing the exergame in the future rather than engage in traditional exercise (p=.008). Results for challenge mirror our findings regarding physical exertion with exercise being the most challenging, followed by the exergame condition, and the sedentary condition (all differences significant with p<.05). The sedentary game was seen as easier to learn than the exergame (p=.007) and the exercise condition (p≈.000). Finally, the exergame condition was rated as more exciting than the sedentary condition (p=.005).

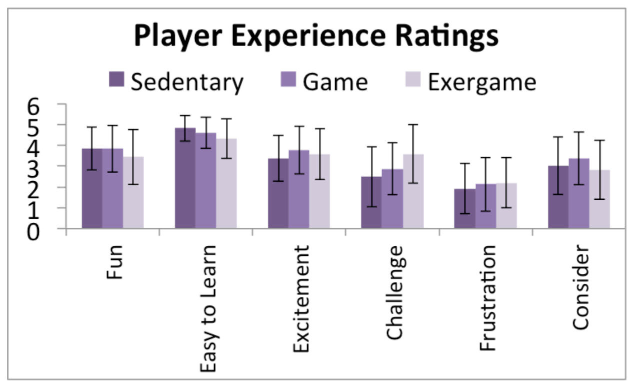

Figure 4. Means and SDs for player experience ratings (on a scale from 1 to 5; 5 is highest).

Given the player experience results, we can conclude that a sufficient number of players found the exergame sufficiently more enjoyable than traditional exercise and easy enough to learn to warrant its consideration for inclusion in the classroom.

FOLLOW-UP SURVEY ON ATTITUDE ABOUT EXERCISE

To gain further insights into the potential application of exergames in a classroom setting, at five months post-study, the same group of children provided ratings and explanations of their exercise attitudes gathered during the experiment (but reported below).

We posed a series of questions about the perceived attentional benefit of exercise because teachers felt that exercise can help students focus on subsequent classwork and research results show benefits of casual exergames on attention in adults [9]. We wished to determine if the students' perceptions matched that of educators and the literature. Participants answered the questions three times:

prior to the study (baseline), right after the study (post), and five months after the study had been completed (follow-up). Results (Figure 5) show that participant attitudes are neither overly positive nor negative towards exercise.

"I can concentrate better shortly after I exercise."

A Friedman Test for related samples showed significant differences in the ratings for agreement with this statement at three different times (χ^2_2=18.9, *p*≈.000). Pairwise comparisons showed that agreement with this statement was significantly lower in the 5-month follow-up survey than in the baseline survey (*p*=.042) or post experiment (*p*≈.000). There was no difference between the baseline and post-experiment surveys (*p*=.118).

Participants were generally able to observe what is going on in their bodies during and shortly after exercise. They gave reasons such as *"I am happy after I exercise"*, *"It helps get blood flowing to my head"* or "*I feel awake"*. Participants holding negative opinions often mentioned that exercise made them tired, such as *"I am tired after exercising and can't think straight"*. Other reasons included that they found exercise makes no difference *"It doesn't really change"* or they forgot what they were doing before exercise *"Not really because I usually forget what I was doing before exercising sometimes"*. Participants with neutral opinions mentioned that whether short bursts of exercise can improve concentration depended on the type and intensity of activity and length of recovery: *"It depends how hard I exercise", "Depends on what the exercise is", "If I am tired I can't concentrate so it depends on what I did"* and *"Right after an exercise, you're still recovering, so you will concentrate fairly after a exercise"*.

"Playing an exercise game can help me to improve my concentration."

We found a main effect of agreement with this statement at the three different survey times (χ^2_2=8.1, *p*=.018). Again, pairwise comparisons showed that agreement in the 5-month follow-up survey was significantly lower than in the post-experiment survey (p=.047), and marginally lower than in the baseline survey (*p*=.066). There was no difference between the baseline and post-experiment surveys (*p*=.878).

Some participants mentioned playing exercise games could give them a break: *"I just "exercise" my brain, gives it a break sometimes"*. Some participants mentioned games are fun, can make people compete and help in learning things: *"Exercising will improve your concentration but the game will make you compete more", "Helps me learn things"* and *"They are usually fun and I will continue thinking about it"*. Most participants who held negative views explained they did not notice the difference between playing an exergame or sedentary activities on their ability to concentrate. One participant mentioned he/she prefers other activities: *"I prefer to just play silent ball or something less extravagant"*. Similar to previous statements on the effects of traditional exercise, participants with neutral opinions mentioned that whether an exercise game could improve concentration depended on the type of game and the intensity of physical activity required to engage in play: *"It depends on how much exercising this game gives to me"*.

"I concentrate better if I exercise regularly."

We found a main effect of agreement with this statement for all surveys times (χ^2_2=14.8, *p*=.001). Again, pairwise comparisons showed significantly lower agreement with this statement in the 5-month follow-up survey than in the baseline survey (*p*=.014) or the post-experiment survey (*p*=.006). There was no difference between the baseline and post-experiment surveys (*p*=.759).

Many participants agreed with the statement through experience. *"My dancing classes stop usually around June or July. This year they have stopped in May and I am finding it harder and harder to concentrate in my class", "If I exercise half an hour before I need to concentrate I work well"*. The explanation for most participants who held negative options was they did not notice the difference between exercising regularly *"I don't think it makes much of a difference"*. Again, participants with neutral opinions mentioned that the impact of regular exercise on concentration depended on the context: *"It depends on the exercise and the time of the day", "Usually depends on the day and if I am feeling tired or not"*.

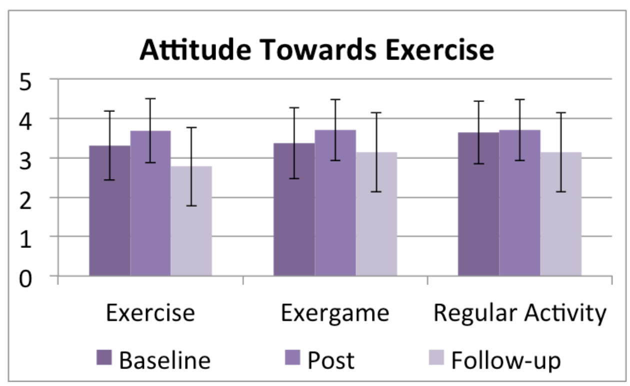

Figure 5. Means and SDs for questions related to perceived attentional benefits of being physically active (on a scale from 1-5; higher indicates more agreement).

Summary

On a general level, the five-month follow-up explanation surveys showed a range of opinions. Many participants stated that they do believe that exercise can have a positive effect on concentration, while some claimed that they did not notice any effects of exercise on concentration. Those who reported a negative impact of exercise or exergames on concentration frequently stated that it made them feel tired, thus reducing their ability to concentrate and potentially interrupted their workflow. This suggests that students have insight into the effects of physical activity on their ability of participating in cognitively challenging tasks, which needs to be taken into account when designing casual exergames to be played in a classroom setting.

Student perception of exergame-based impact on their attention was mixed and produced no significant differences between activities. This result then satisfies our final requirement, that the game not be disruptive to students. The exergame was no better or worse than sedentary or body break activities on perceived ability to concentrate. The decrease in attitude towards exercise could be a manifestation of age-related attitude changes noted by both the teachers and the literature, as discussed earlier.

DISCUSSION

We present our contributions and findings, followed by a discussion of casual exergame deployment in schools.

Contributions and Findings

The teachers' observations about their students' physical activities at school provided valuable opinions both on the nature of exercise in pre-adolescence and on the potential for casual exergames to help improve physical activity among schoolchildren. The teachers noted that students become more sedentary, less motivated and less interested in exercise when they grow older and most teachers already integrate physical activities into classroom activities, such as stretches and dance, to help students reenergize between class breaks. Teachers also noted that students enjoy short chunks of physical activity, which anecdotally seems to have positive effects on concentration. Similarly, teachers found that after PE class, students were often ready to learn.

Our results show that the exercise and exergame condition both provided intense workouts. The exergame condition demonstrated moderate to vigorous exertion, and the exercise condition created workouts at near maximum intensity, both in terms of objectively-measured heart rate and subjectively-measured exertion. The similarities in heart rate and ratings of perceived exertion show that students were able to rate the intensity at which they exercised, suggesting that they understood the physiological signals of exertion, and were able to subjectively evaluate exercise intensity. This is an important insight for exergame design: if students can accurately self-rate exercise intensity, then self-paced exergames can tailor the physical challenge necessary to produce optimal levels of exertion for health benefits and player engagement. They also show that exertion levels in the exercise condition were very high, exhausting students physically after 10 minutes, which the students felt affected their ability to concentrate.

The results of the player experience survey showed that students had more fun playing the exergame than doing traditional exercise. Moreover, students would consider playing an exergame during a break more than they would consider doing traditional exercise. Our participants rated traditional exercise as a fun activity as our sample consists of children who are generally fond of exercise, and the PE teacher made the exercise session fun and motivating. The students enjoyed the exergame more than traditional exercise and indicated they would play the exergame more than traditional exercise if they had 10-minutes of free time in a day, such as in breaks between classes.

We noted a significant decrease in opinions on exercise after the study, but no significant difference between any of the activities themselves, indicating that exergames should not have negatively impact concentration.

Overall we have successfully demonstrated that exergames are acceptable to teachers, provide sufficient and targeted exercise needs, are more enjoyable and easier to learn than traditional exercise and have a negligible effect on student concentration. In aggregate, we believe we have demonstrated that properly designed exergames can be used in the future as antisedentary interventions in classrooms.

The Deployment of Casual Exergames in Schools

The goal of our work was to explore how casual exergames can be deployed in schools to give kids the physical activity they require, and the cognitive advantages that result. Contrary to earlier work [13], our findings demonstrated that self-paced exergames can produce exertion levels in the children that meet current guidelines of physical activity.

The students' explanations of their attitudes demonstrated that they understand the cognitive advantages of exercise, and that they felt that too much exertion without sufficient time for recovery negatively affected their ability to concentrate. Some of the students mentioned that this problem could be addressed in the design of casual exergames, ensuring an intensity level within recommended guidelines. Our causal exergame produced exertion levels within the recommended guidelines, suggesting that the students paced themselves effectively.

Teachers were also interested in integrating casual games in the classroom to increase students' physical health and increase their focus after playing such games, and to decrease long stretches of sedentary time. Teachers noted that casual exergames have advantages over exercise by allowing students to have more control and being able to track students' physical activities individually. Teachers provided practical concerns, such as lack of space, disruption of others and cheating when playing the game. For example, classroom space varies among schools, so the location of an exergame system within the school (e.g. in a classroom or common area) must be addressed on a case-by-case basis. Teachers noted that students might cheat during play, so exergames should be robust enough to prevent students from gaming the input device or game mechanic. Finally, teachers reported different ideas on how exergames might be integrated into the classroom, such as letting students take turns like a relay race, letting interested students sign up, or using these games as a reward.

Limitations and Future Work

Our results show the potential possibilities of casual exergame deployment at schools; however, there are limitations in what we can infer from our studies leading to new research opportunities.

Our participants may not be representative of the general population of pre-adolescent schoolchildren. They come from a privileged neighbourhood, are high achieving, and are in a pilot educational program on staying healthy. Our results may not extend to children who are physically inactive or who have a different socioeconomic status.

The students in our study played the casual exergame for only ten minutes and the novelty of the Kinect-based game may have affected the players' perceptions of its fun. Outside of the context of our study, we do not know how motivated students would be to play a casual exergame over the longer term. Our study is the first step to investigate the potential of casual exergames in schools; the next logical step will be to develop casual exergame design guidelines for classroom use and deploy a suite of casual exergames in a classroom as a longitudinal study to determine the long-term efficacy of casual exergames as a pre-adolescent school-mediated health intervention for reducing sedentary time, and long-term player engagement, particularly during voluntary breaks such as recess.

Our work used a single casual exergame. It would be worthwhile to investigate the inclusion of other properly designed motivational elements, such as leader boards, classroom competition, or cooperative multiplayer games in a social context [18, 31].

Finally, the ultimate success of this work would be to evaluate the longitudinal health effects of a suite of well designed exergames and demonstrate measurable health effects by reducing sendentary behavior. This would be a sophisticated and difficult experiment to conduct to meet the burden of proof expected in the medical community. However, the results we have presented here indicate that it may be worth working towards this type of investigation.

CONCLUSIONS

Although the physical importance of breaking up sedentary time and the positive effects of physical activity on learning processes are widely known, schools struggle to provide sufficient opportunities for physical activity to their students. This effect is particularly apparent as students transition from childhood to adolescence. Casual exergames may be a means of encouraging physical activity amongst pre-adolescences and breaking up long stretches of sedentary behaviour. Due to the special characteristics of these games (interruptible, short chunks of play, easy setup routines), they are well suited for deployment in schools for play during natural breaks in the school day, such as at lunch or recess. We have demonstrated that students see the benefits of moderate physical activity throughout the day, and that they enjoy engaging with a casual exergame as a preferable alternative to traditional exercise.

Casual exergames have also been applied to help people regain focus during crucial periods of their day and yield acute cognitive benefits. Students demonstrated a mature understanding of the relationship between cognition and activity level. Further evidence of the utility of casual exergames in a school environment was provided by teachers who noted several methods where exergames could be successfully deployed in a classroom setting. This work in aggregate makes a strong case for the utility of casual exergames in a classroom setting to help break up sedentary time, thus avoiding the negative health outcomes that can result from sitting still for too long at school.

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