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The influence of active gaming on cardiorespiratory fitness in black and Hispanic youth

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Abstract

BACKGROUND—Youth in the United States have low levels of cardiorespiratory fitness, a risk factor for childhood obesity. Lower levels of physical fitness for black and Hispanic youth contributes to health disparities. In this feasibility study we examined active video games (AVG) as a tool to improve fitness and attitudes towards physical activity during early adolescence.

METHOD—A 6-week AVG program took place in a youth development program in a high poverty neighborhood in New York City. Youth aged 10 to 15 years (50% overweight or obese) participated in 2 fitness tests and completed surveys that captured barriers to physical activity pre- and post-intervention. Each week, participants played Wii Fit games for 30-minutes.

RESULTS—Participants improved the number of sit-ups and step-ups they completed from pre- to post-intervention ($p < .05$). Participants also increased their self-efficacy, intention to exercise and perceived social support to exercise ($p < .05$). Youth reported a high level of enjoyment and perceived Wii Fit as ways to increase physical fitness and increase their physical activity.

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CONCLUSION—AVGs may be a viable alternative exercise program to increase physical activity for black and Hispanic youth living in poverty-impacted neighborhoods.

Keywords

video games; cardiorespiratory fitness; physical fitness; adolescent

Only 8% of 12-to-15-year-olds in the United States (US) engage in the recommended amount of physical activity of one hour daily.[1,2] This lack of physical activity has been cited as a contributing factor to the childhood obesity epidemic,[3] which increases the risk factors for cardiovascular disease.[4,5] Furthermore, only 42% of US adolescents have adequate cardiorespiratory fitness.[6] Low level of fitness in ethnic minorities has been proposed as a key contributor to health disparities[7,8] particularly during early adolescence as physical activity declines[9] while obesity incidence increases.[10] Increasing physical activity is a key component to reducing obesity[11] and improving cardiorespiratory fitness.[12] The current study examined active video games (AVG) as a way to improve fitness and attitudes towards exercise for adolescents enrolled in a summer camp.

Active Video Games as Fitness Interventions

AVGs may ameliorate cardiovascular risk factors as these games increase physical activity[13] and exercise self-efficacy[14] as youth are motivated and engaged when playing.[15,16] AVGs may be an effective, sustainable physical fitness intervention as they are portable and can be played in a wide range of environments such as at home, school, or community center.[17,18] Even with limited space and resources, AVGs can be fitness tools that are easy to implement in community settings including in-school and after-school settings.[14,19,20] Past research on AVGs has shown that these physically-active video games are a viable source of physical activity for children. When adolescents play AVGs, they expend energy at a moderate intensity, similar to other physical activity.[21,22,23] For example, Graf et al observed that the energy expenditure of 10-to-13-year-old children was similar when playing the AVG Dance Dance Revolution (DDR) and when walking at a moderate intensity on a treadmill.[24]

Players have displayed enjoyment and positive attitudes while exergaming, and some studies have found that interventions with AVGs produce higher positive affect than when adolescents participate in non-interactive or non-AVG exercise.[25] AVGs often involve partner play, which is important given research indicating that youth are more likely to be motivated to exercise if they have social support or if a friend exercises with them.[9] One study examined 10-year-old children playing a dance AVG, similar to DDR, for 12 weeks finding those in a multiplayer classroom were twice as likely to play and less likely to drop-out of the study compared to children in a home intervention who played the AVG alone.[26]

In addition to the enjoyment involved in AVG play, youth are able to perceive that they are exerting energy while playing AVGs. Research found that children's perceived exertion during DDR and Wii Sports Boxing was higher than walking moderately on a treadmill.[24] Young adults who played DDR continued to play the game because of the health benefits of improved coordination and rhythm and continued to play because they felt personally

challenged.[27] Perceived exertion and challenge may be important factors in helping children build self-efficacy in their own physical fitness abilities.

Current study

The specific aim of our feasibility trial was to examine if a 6-week AVG intervention increased adolescents' physical fitness, exercise self-efficacy, intention to exercise, and perceived social support for exercise. We had 2 hypotheses.

Hypothesis 1: Based on previous research indicating youth can exert energy after AVG interventions, it was hypothesized that youth would increase their physical fitness from pre- to post-intervention.

Hypothesis 2: Prior evidence indicates that as children increase their physical fitness, there may be concimitant benefits such as increased enjoyment and self-efficacy in physical ability. Therefore, it was hypothesized that participants would increase their intention to exercise, exercise self-efficacy and perceived social influences from pre- to post-intervention.

METHODS

Context and setting

The research study took place at a 6-week summer camp targeting a poverty-impacted neighborhood in New York City (NYC) serving black non-Hispanic, black Hispanic and Hispanic youth during the summer of 2010. The program took place at a school that serves youth who are 100% eligible for free and reduced lunch and almost half (44%) of the families in the neighborhood live below the Federal Poverty Level, making it the poorest neighborhood in NYC.[28] In addition, the neighborhood has the highest level of unemployment, the highest jail incarceration rate (4 times the average), and the third highest number of violent crimes in NYC.[28] In terms of health, the neighborhood fares more poorly than the average NYC neighborhood with the highest prevalence of obesity (35% of the population) and diabetes (16% of the population).[28]

The youth development program, which provides summer enrichment and youth development opportunities serving over 400 youth from the neighborhood each summer, was seeking ways to increase physical activity for their participants. Summer camp administrators were interested in including AVG sessions into the program, as they identified several barriers to exercise for the youth in their program. First, the program had limited access to safe outdoor spaces because of high crime.[20] Second, the program had limited indoor spaces that could be used for movement-based activities. The one gym in the building had to accommodate all 400 youth in the summer program as well as other youth development programs. Third, the summer camp staff found it difficult to motivate the youth in the program to exercise. Program staff stated that many of the youth did not like exercising or playing sports, and they disliked going outside because it was dirty and unsafe. AVG sessions were an appealing addition to the summer camp program administrators because the games provided an alternative, enjoyable activity that would get youth physically moving in a classroom.

Participants

The participants were 126 adolescents aged 10-to-15 years (M = 12.60 years, SD = 1.7; 51.6% female). Parents were asked to write in their ethnicity on a demographic survey; however, 40% of parents did not respond to this question. Of those who responded, parents self-identified as 36.4% Hispanic, 26% black, 12% African-American, 6.5% Spanish, 6.5% African, 4% black Hispanic, 4% Latino, 3% Dominican, 1.3% Puerto Rican, and 1.3% biracial. Due to the large amount of missing data, ethnicity was not included in the analyses. Consent was obtained from parents before the study began. Youth participants provided oral and written assent before the first session and were informed that they could drop-out of the study at any point during the summer while still having the option of attending the AVG sessions.

Materials

Nintendo Wii Fit—The intervention utilized Nintendo's Wii Console and the Wii Fit AVG. Wii Fit, an exercise-based game based on controlled movements, is played using a balance board. Players stand on the balance board and games require physical motion, core strength, and balance. Some games require arm movements; therefore, players hold the Wiimote controller while playing. A motion-sensor bar placed on top of the television detects movements through the Wiimote and Wii Fit.

Nintendo games—Children played a variety of Wii Fit aerobics games and balance games, including hula-hoop, step aerobics and jogging. The game was Wii Fit Plus, which is rated "E" for everyone. The games were accompanied by music and had audio and visual instructions and cues throughout the exercise. The game provided progress screens at the end of each exercise. Progress was tracked with level achieved (number of stars or points accrued) and fitness achievement (calories burned).

Procedure

Youth participated in a one-hour class session each week for 6 weeks during summer camp. Sessions took place in a classroom with 8 stations equipped with a flat screen 32-inch television, Nintendo Wii game console, 2 Wiimotes, and a Wii Fit balance board. Children were randomly split into dyads and assigned stations for the summer. Each child played the games for a 30-minute work-out within the hour-long session. Each child played at her or his own station while her or his partner helped record the child's progress. Camp counselors accompanied the children to the sessions and were present to support the children in these sessions. A trained research assistant who had a master's degree in physical education and was a licensed teacher by the State of New York led the sessions. During the first session, the research assistant administered the baseline physical activity and media use surveys, measured BMI, and conducted the fitness measures. Youth followed the specific exercise routine designed by the investigator for the day by recording their progress on their exercise log. The last session was conducted during the sixth week of the summer program. During the last session the research assistant administered the follow-up physical activity and media use surveys, measured BMI, and conducted the fitness measures again.

Weekly fitness games—In each session, the participants played 3 games: Hula Hoop Basic or Super Hula Hoop, Table Tilt, and Basic Step. After completing their weekly games, participants played several other games. By the end of the sessions, participants had played all Wii Fit games available. As a warm-up, participants played *Hula Hoop Basic* (for one minute in week 1) or *Super Hula Hoop* (for 3 minutes in weeks 2 to 6). The goal of these games is to spin the hula-hoop as many times as possible in the designated time frame while keeping a steady quick motion and center of balance. The *Table Tilt* game, which requires balance and spatial relations, was the second game participants played weekly. The goal was to navigate one or more balls through a maze using center of balance. The game increases with difficulty as players are successful. Youth played the *Table Tilt* game for as long as they were successful at the game and kept advancing levels. The third game participants played weekly was the game *Advanced Step.* The advanced step requires stepping up and down on to the Wii Fit balance board in a variety of directions to the music. After they had played the 3 designated games, participants were able to choose different Wii Fit Plus games that worked on balance and fitness for about 10 minutes each session. For example, participants could choose an obstacle course game in which the participant runs in place on the balance board to negotiate various obstacles.

Outcomes Measures

Physical fitness—Two physical fitness measures were administrated pre- and post-intervention: sit-ups and step-ups. Sit-ups were selected as a fitness assessment that measures abdominal strength and endurance, given the Wii Fit games require balance and core strength, and because sit-ups can be compared to the national Presidential Fitness Guidelines.[29] Participants were partnered with a peer. Partner 1 was instructed to lie on the ground with her or his knees flexed and feet about 12 inches from her or his buttocks and arms crossed so that hands were placed on opposite shoulders. Sit-ups required participants to curl their trunk until their elbows touched their thighs and then lower back to the floor until their shoulders touch the floor. Partner 2 was instructed to hold Partner 1's feet and count the number of sit-ups aloud. The research assistant demonstrated the movement, and staff assisted to ensure all youth understood the motion. Only complete sit-ups were counted. The research assistant called out "Ready? Go!" and timed the participants for one minute then called out "Stop" at the end of one minute. The research assistant recorded the number of sit-ups each participant completed.

Step-ups, an exercise that measures cardiovascular endurance, was measured at baseline and at the end of the study. This exercise was conducted using the Wii Fit's *Free Step Game*, which had participants step on and off the Wii Fit balance board for 3 minutes. Youth were instructed to step up with one foot and then the other and then step down with one foot followed by the other, while trying to maintain a steady consistent 4-count pace, "up, up, down, down." At the end of the 3 minutes, the Wii Fit, displayed the total number of step-ups the participant completed, which was recorded by the research assistant and summer camp staff.

Reynolds Influences of Physical Activity—The Reynolds Influences on Physical Activity scales[30] were used to measure youth's attitudes towards physical activity. The 3

subscales have been reliable and valid psychosocial predictors of physical activity: self-efficacy (α = 0.89), intention to exercise (α = 0.68), and social influences (α = 0.55).[30,32] Combined, these scales cover barriers to adolescents' physical activity.[31] Participants rate the 13 items are rated on a 1 (*strongly agree*) to 6 (*strongly disagree*) scale. Example questions include "I am confident that I can motivate myself to exercise even when I am feeling down" (self-efficacy), "I intend to get regular exercise when I am older" (intention to exercise), and "Other members of my family exercise regularly" (social influence). Relatively well internal consistence was found: self-efficacy (8 items; α =0.91), youth's intention to exercise (3 items; α =0.79), and social influence (2 items; α =0.57).

Post-intervention survey—At the end of the intervention, participants took a survey of 5 questions that measured their experience with Wii Fit. First, participants responded to the question, "How much did you like playing Wii Fit?" on a 4-point scale from 1 (*really don't like playing*) to 5 (*really like playing)*. Then participants rated how easy the Wii Fit was to use from 1 (*very difficult*) to 5 (*very easy*). Participants answered if they thought the Wii Fit was a good activity to have at school in physical education classes, rated from 1 (*worst activity*) to 5 (*great activity*). Finally, participants indicated if they believed Wii Fit could help other children get fit, if Wii Fit helped them get fit, and if Wii Fit made them more physically active. These questions were rated on a 1 (*strongly disagree*) to 5 (*strongly agree*) scale.

Covariates and Descriptive Characteristics

Media use surveys—Participants completed a media use questionnaire on their attitudes about and exposure to media, household media environment and media habits. This questionnaire was based on a media survey for children.[32] Participants were asked if they had ever played Wii Fit before and how often they had played previously, which was rated from 1 (*played once or twice*) to 5 (*play almost daily*) scale.

The Physical Activity Questionnaire for Children—The Physical Activity Questionnaire for Children (PAQ-C), a reliable and valid measure of physical activity levels, was used to measure participants exercise habits prior to the intervention (α = 0.83).[33,34] Regular exercise was defined as 3 times or more per week for 20 minutes or longer. Participants circled "yes" or "no" for each of the following questions: I currently exercise; I intend to exercise in the next 6 months; I currently exercise regularly; and I have exercised regularly for the past 6 months.

Body mass index—Weight was measured to the nearest 0.1 kg privately by the research assistant using a digital Tanita Body Composition Scale. Height was measured using the US Centers for Disease Control and Prevention[35] recommendations to the nearest 0.1 centimeter. BMI (kg/m^2) was used as a covariate in the analysis, and BMI percentiles were calculated from the CDC SAS macro program based on the sex, height, and age of the child.[36]

Data Analysis

Data analyses were performed in SAS Version 9.4. A mixed-effect linear regression model was used to model the baseline and follow-up responses using an intent-to-treat approach. Sex, age, BMI, previous experience playing Wii Fit and intention to exercise at baseline were used as covariates and chosen *a priori*. The primary reason for including these covariates in the model was to account for potential differences in response. Correlation between times was adjusted for using an unstructured covariance matrix. Time differences were assessed using the least square means estimated from the mixed model.

RESULTS

Preliminary Analysis

Descriptive statistics of baseline covariates are as follows. About half of the sample had prior experience playing Wii Fit (48%). Most participants reported that they currently exercise (68%) and intend to continue exercising for the next 6 months (62%). However, fewer participants reported exercising regularly (48%) or had exercised regularly for the 6 months prior to the intervention (38%). The average BMI before the intervention was 21.60 (SD = 5.30) and at the end of the intervention was 21.16 (SD = 6.17). BMI percentiles indicated that 60% of participants were normal weight (below the 85th percentile), 17% were overweight (85th to 95th percentile), and 23% were obese (95th percentile or higher).

Change in Fitness and Barriers to Physical Activity

A mixed-effects regression model controlling for sex, age, BMI, previous experience playing Wii Fit and prior regular exercise covariates at baseline showed significant changes in fitness (Table 1) and barriers to physical activity (Table 2). The number of sit-ups significantly increased from pre- (M = 25.00, SE = 1.15) to post-intervention (M = 30.00, SE = 1.48) ($p = 0.003$). The number of step-ups from pre- (M = 103.00, SE = 3.82) to post-intervention (M = 132.00, SE = 4.93) significantly increased ($p < 0.001$). There was also a significant increase from pre- (M = 2.38, SE = 0.09) to post-intervention (M = 2.77, SE = 0.13) in self-efficacy ($p = 0.005$). Intention to exercise increased from pre- (M = 2.04, SE = 0.09) to post-intervention (M = 2.46, SE = 0.12) ($p = .002$). Social support for physical activity also significantly increased from pre- (M = 2.39, SE = 0.09) to post-intervention (M = 2.76, SE = 0.13) ($p = .014$).

Post-intervention Enjoyment and Perceptions

After the intervention, most participants reported high levels of satisfaction with the intervention; almost all participants indicated that they liked or really liked playing Wii Fit (90%). Most participants found the Wii Fit easy to use (70%). Participants also thought Wii Fit would be a good activity at school in physical education classes (80%). Most participants believed that children could become fit by playing Wii Fit (80%). When rating their own fitness experience during the intervention, participants believed that Wii Fit helped them get fitter (72%) and thought it helped them be more physically active overall (66%).

DISCUSSION

We demonstrated that AVGs are a feasible and enjoyable fitness activity for youth. Changes in youth's fitness, self-efficacy, intention to exercise and social support were observed after a 30-minute, weekly AVG session for 6 weeks. In addition, youth reported high levels of enjoyment and perceived the AVG as a viable way to increase fitness. Cardiorespiratory fitness improved in these youth, including an average 20% increase in sit-ups and 28% increase in step-ups. The improvement in sit-ups from 25 to 30 per minute is an improvement from marginal to good fitness for boys and a maintenance of good fitness for girls.[37] However, these scores are all below the 85th percentile according to the national norms for the Presidential Physical Fitness Award.[29] In one of the only studies published on fitness improvements following AVG interventions, Gao et al[20] did not observe improvements in a 0.5 mile run after a 6-week AVG intervention for urban elementary students. Our study presents novel data on improvements in fitness following a 6-week AVG intervention, with the noted limitation that there was no control group for comparison.

Despite the lack of a control group, including AVG sessions in a youth development program that had limited access to safe outdoor spaces and limited large indoor spaces for physical activity reduced some of the external barriers to youth participation in physical activity. In addition, the community atmosphere and support from peers and staff may have reduced some of the key psychosocial barriers to physical activity.[18] Children in this AVG intervention increased in self-efficacy, intention to exercise, and perceived social support to exercise. Improving youth's self-efficacy is an important step in increasing physical activity as research has found that children with high self-efficacy engage in physical activities and exercise more than their peers.[30,31] Intention to exercise and perceived social support are also important factors in increasing the physical fitness of youth, as individuals' intention to perform an action, such as a physical activity, is influenced by both their attitude toward the action and their perception of social norms.[38] For instance, a child who intends to engage in physical activity but believes her or his friends would discourage it will be less likely to engage in the activity. On the other hand, a child who dislikes physical activity but perceives fitness to be the social norm may be more likely to engage in the activity.

A strength of the current study is that it was conducted in an authentic community-based setting with a population of youth that is often under-served and under-researched.[18] School and aftercare programs need innovative fitness programs, particularly considering black non-Hispanic, black Hispanic, and Hispanic youth, as well as youth from high poverty backgrounds, are more at risk for obesity their white middle class counterparts.[7] Consequently, programs that increase cardiorespiratory fitness for these youth have potential to reduce health disparities.

Limitations

We demonstrated the feasibility of using AVGs in community-based settings; however, the findings should be interpreted with the following limitations considered. First, there was no comparison or control group, so it is not known if the fitness improvements and other changes were due to external factors like natural growth or participation in the summer camp. Youth may have been more active over the course of the summer and the youth

development program had other movement-based activities. Second, the measures of previous exercise and barriers to physical activity were self-reported, though these measures have been validated with this age range. Third, there were no follow-up data collected to ascertain if students' interest in the Wii Fit activities sustained after the summer camp ended. Prior studies have indicated that youths' interest typically wanes in specific active video games,[39,40] though one trial achieved 79% adherence to 36 hours of AVGs over a 12-week period[23] and another trial sustained adolescents' engagement to weekly AVG play for a 20-week period.[22] Future research should investigate potential sustainability of AVG play after an intervention ends.

Finally, the current study did not use a measure of energy expenditure, such as an accelerometer or heart-rate monitor; thus, the extent of participants' actual energy expenditure is unknown. However, a body of research conducted in controlled laboratory settings has demonstrated that AVGs can provide moderate to vigorous physical activity.[41–43] which means it is likely that participants in the current study were exerting energy at a moderate to vigorous intensity. Indeed, participants themselves reported a belief that the Wii Fit activities could increase their own physical fitness. Future research should investigate other potential health outcomes from extended AVG play including improvements in markers of cardiovascular and metabolic health and maximal cardiorespiratory fitness using a treadmill or cycling test.

Conclusion

We found evidence that AVGs are an enjoyable exercise intervention that can improve adolescents' fitness and attitude towards physical activity. The study took place in a poverty-impacted neighborhood in NYC with few opportunities for physical activity. To increase physical activity for youth, interventions need to be enjoyable, set feasible goals and improve self-monitoring.[18] AVGs may be a viable way to increase physical activity in school and community-settings, particularly for youth who face barriers to traditional exercise options

IMPLICATIONS FOR SCHOOL HEALTH

Research shows that youth may be inactive due to few safe outdoor spaces, inadequate in-school physical activity or lack of access to facilities in schools or community-based programs.[44] Schools are a key setting for making physical activity more accessible for youth and reducing health disparities, however schools in poverty-impacted neighborhoods often do not have the resources or facilities to address and reduce all the barriers to exercise. There is a need for affordable interventions that are contextually flexible, yet enjoyable to children of all ages. AVG are a fairly low cost and portable exercise solution that can take place in smaller spaces, such as a classroom. This type of program could be executed by the school or in partnership with a community-based organization as it could occur at recess or before or after school. In addition, AVGs could be incorporated into physical education classes as part of a comprehensive fitness program. In the current study a licensed physical education teacher supervised the program; however, that is not necessary for implementation as the AVG provides direction and support. AVGs are enjoyable for all ages and this program could

be implemented in elementary or secondary schools. Implementing an AVG program into schools, especially in poverty-impacted neighborhoods, is a convenient solution for reducing barriers to physical activity.

Human Subjects Approval Statement

The research presented was conducted according to the APA Ethical Principles and was reviewed and approved by a University of California, Riverside, Human Review Board assigning “Extertainment: The Contribution of Fitness Gaming to Youth Health” a Human Subjects Protocol number of HS-10-037.

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Table 1

Fully Adjusted Mixed Effect Linear Regression Models of Change in Primary Fitness Variables after the 6-week Exergaming Intervention

	Sit Ups		Step Ups	
	B	**p-value**	**B**	**p-value**
Time	5 ± 2	.003	29 ± 6	<.001
Sex (Boy)	5.0 ± 2.0	.003	−0.6 ± 5.5	.917
BMI	−0.5 ± 0.2	.004	−0.5 ± 0.5	.366
Age	0.7 ± 0.5	.220	7.2 ± 2.0	<.0001
Previously Played Wii Fit	−4.0 ± 2.0	.024	−8.0 ± 5.6	.154
I currently exercise	1.7 ± 2.4	.485	3.7 ± 7.6	.629
I intend to exercise in the next 6 months	−4.5 ± 2.0	.027	−4.6 ± 6.4	.479
I currently exercise regularly	−0.2 ± 2.2	.91	0.4 ± 7.0	.955
I have exercised regularly for the past 6 months	−2.6 ± 2.0	.203	−21.0 ± 6.5	.002

Table 2

Fully Adjusted Mixed Effect Linear Regression Models of Change in Primary Barriers to Exercise Variables after the 6-week Exergaming Intervention

	Self-Efficacy		Intention to Exercise		Social Support	
	B	**p-value**	**B**	**p-value**	**B**	**p-value**
Time	0.4 ± 0.1	.005	0.4 ± 0.1	.002	0.4 ± 0.2	.014
Sex (Boy)	−0.03 ± 0.2	.865	−0.1 ± 0.1	.406	−0.2 ± 0.2	.159
BMI	−0.02 ± 0.01	.276	0.02 ± 0.01	.135	−0.003 ± 0.01	.785
Age	−0.1 ± 0.1	.263	−0.1 ± 0.04	.101	−0.1 ± 0.1	.277
Previously Played Wii Fit	0.3 ± 0.2	.044	0.1 ± 0.1	.372	0.1 ± 0.2	.555
I currently exercise	0.1 ± 0.2	.805	0.1 ± 0.2	.736	−0.03 ± 0.2	.898
I intend to exercise in the next 6 months	0.3 ± 0.2	.116	0.5 ± 0.2	.004	0.3 ± 0.2	.090
I currently exercise regularly	0.2 ± 0.2	.249	0.2 ± 0.2	.286	0.2 ± 0.2	.356
I have exercised regularly for the past 6 months	0.3 ± 0.2	.087	−0.03 ± 0.2	.002	0.4 ± 0.2	.854