Video Game–Based Exercise, Latino Children's Physical Health, and Academic Achievement

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Background: There is a paucity of research investigating the effects of innovative physical activity programs on physical health and academic performance in the Latino population.

Purpose: To examine the impact of Dance Dance Revolution [DDR]–based exercise on Latino children's physical fitness and academic achievement.

Design: A repeated-measures crossover design was used. In Year 1, Grade-4 students were assigned to the intervention group and offered 30 minutes of exercise (DDR, aerobic dance) three times per week. Grade-3 and Grade-5 students made up the comparison group and were offered no structured exercise at school. In Year 2, the Grade-4 students were again assigned to the intervention, whereas Grade-5 and Grade-6 students were in the comparison group.

Setting/participants: Assessments were conducted with 208 Latino school children.

Main outcome measures: The baseline measures included time to complete a 1-mile run, BMI, and reading and math scores. Data were collected again 9 months later. Overall, data were collected in 2009–2011 and analyzed in 2012.

Results: Data yielded significant differences between the intervention and comparison groups in differences in 1-mile run and math scores in Year 1 and Year 2. The results also revealed net differences in the intervention versus comparison group scores on the 1-mile run for Grade 3 ($p<0.01$). Additionally, children's yearly pre-test and post-test BMI group changes differed ($\chi^2_{(2)}=6.6$, $p<0.05$) only for the first year of intervention.

Conclusions: The DDR-based exercise intervention improved children's cardiorespiratory endurance and math scores over time. Professionals should consider integrating exergaming at schools to achieve the goals of promoting a physically active lifestyle and enhancing academic success among Latino children.
(Am J Prev Med 2013;44(3S3):S240–S246) © 2013 American Journal of Preventive Medicine

Introduction

The health status and academic performance of underserved minority children continue to be concerns in the U.S.[1] Specifically, Latino children are disproportionately more overweight and obese,[2] and they fare worse on academic reading and math tests than non-Latino white children.[3,4] Thus, there is an urgent need to examine new ways of improving physical health and academic outcomes of this group.

Given that participating in regular physical activity is critical to preventing and reducing obesity in children,[1,2,5] promoting physical activity participation in school-aged children has become an important public health priority.[5] Also, regular participation in physical activity is either positively associated with academic performance[6–9] or does not adversely affect academic performance[10,11] when instituted within the school day.[12] Additional studies are needed to investigate the effects of innovative physical activity programs on health-related physical fitness (i.e., fitness related to some aspects of health) and academic performance in the Latino population.

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0749-3797/$36.00
http://dx.doi.org/10.1016/j.amepre.2012.11.023

Exergaming is considered a fun and entertaining way for children to participate in physical activity and develop healthy habits and a fitness-oriented lifestyle.[13,14] For example, Dance Dance Revolution (DDR) is an exergame that combines dancing and fast foot movement with energetic music and visuals. It has been deemed a good type of exercise to promote physical activity.[15] DDR also has been shown to stimulate brain activity through timing and pattern reading, which may lead to increased success in reading and math.[16]

Recent efforts have examined the benefits of exergaming as a means for promoting physical activity.[17–23] However, investigations in the exergaming field have been conducted primarily in laboratory settings with small samples of non-Hispanic white individuals.[19,22,23] No empirical studies have examined the long-term effects of exergaming on underserved Latino children's fitness and academic achievement in population-based settings. Further, most current studies have examined the effects of exergaming on only physical activity levels or energy expenditure,[22–26] not on academic achievement.

The current study examined the impact of a DDR-based exercise program on urban Latino children's cardiorespiratory endurance and BMI status, as well as academic (reading and math) performance. The authors hypothesized that children in the DDR-based intervention would demonstrate greater increases in cardiorespiratory endurance and greater decreases in BMI trajectories than comparison children over 1 school year. Second, the authors hypothesized that children who received the intervention would demonstrate greater improvements in math and reading scores than comparison children over 1 year.

Methods

Participants and Setting

Recruitment of 268 students in Grades 3–5 from an urban elementary school took place in the Mountain West region of the U.S. The vast majority of children were from economically disadvantaged, Latino immigrant families, with parents or guardians generally having minimal education and experiencing unique effects from social and behavioral acculturation to the U.S.[27] Overall, data were collected in 2009–2011 and analyzed in 2012.

The site school had the highest obesity rate in the state of Utah, and performed at an average of 48% of proficiency on the Utah Criterion-Referenced Test in 2008. There was neither a required physical education class nor a physical education specialist at the school. The average class size was 25.

Students generally had two recess periods (15 minutes each) during the school day. With the school's support, the two recesses were combined into a 30-minute physical activity program within the Grade-4 curriculum, and a DDR-based program was set up in the gym to serve these children during the program. Although the DDR-based program was available to all in Grade 4, children were included in the evaluation cohort only if they met study inclusion criteria: (1) aged 10–12 years; (2) from a Latino family; and (3) not diagnosed with a physical or mental disability according to school records. On approval from the University of Utah IRB and the school district, informed parental consent forms and child assent forms were obtained prior to this study.

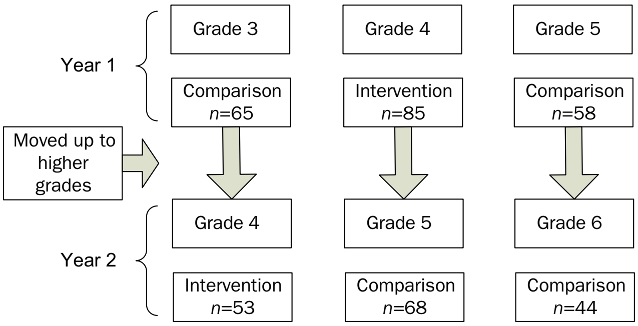

Figure 1. Flowchart of study showing repeated-measures crossover design

Design

A repeated-measures crossover design was implemented (Figure 1). The DDR-based intervention was delivered to the socially intact groups, those in Grade 4 in Year 1, and to those in Grade 4 (originally in Grade 3) in Year 2. Children originally in Grade 4 completed an intervention year followed by a comparison year in Grade 5; children originally in Grade 3 had a comparison year in Year 1, followed by an intervention year in Grade 4. Results obtained from Grade 5 at Year 1 and Grade 6 at Year 2 were used as a comparison, and changes in the outcomes were interpreted as a natural developmental effect.

Participants' baseline fitness was measured in August 2009. Each cohort was then tracked to the second year and higher grade after a 2-month washout period (Summer 2010). The participants completed follow-up fitness assessments in May 2010 (Year 1), and again in August 2010, and May 2011 (Year 2). Math and reading scores were retrieved from the school district at baseline and the end of each school year (three times; Table 1).

Intervention

The intervention for children in Grade 4 involved participating in a 30-minute, DDR-based exercise program three times per week. DDR was initially proposed as the only intervention strategy before initiation of the program. However, based on the pilot study and observations in 2008–2009, a center activity station (e.g., aerobic dance, jump rope) was added in September 2009 because of children's short attention span for DDR. Specifically, the children were split into two groups, which were rotated so that one group played DDR for 15 minutes, and the other group participated in center activities for 15 minutes.

Detailed information regarding how to play DDR is presented elsewhere.[17] A total of eight DDR stations were set up in the gym, with each DDR station accommodating two children. Generally, classroom teachers supervised the class behaviors for the DDR group. For the center activities, research assistants led the children either in aerobic dance, jump rope, or similar types of activities. In the comparison arm (Grades 3 and 5 in Year 1 and Grades 5 and 6 in Year 2), children did not participate in any structured exercise program at school. Rather, they participated in the conventional unstructured recess within the classroom (i.e., sitting or walking) or outside (i.e., playing on the playground) and were monitored by their respective classroom teachers.

Measures

Health-related physical fitness. Data sources in the current study included a cardiorespiratory endurance assessment (1-mile run) and a body composition assessment (BMI as measured by the stadiometer and weight scale). At each measurement occasion, all participants completed a 1-mile run. Times were recorded in minutes and seconds for each participant. Participants were encouraged to run as fast as they could.

Body mass index was dichotomized into two groups: (1) healthy fitness zone or (2) needing improvement from the FITNESSGRAM® individual report. The possible BMI outcomes from August to May were categorized as change from healthy to needing improvement (poorest); no change from needing improvement (poor); no change from healthy (good); and needing improvement to healthy (best). The fitness test was conducted during regularly scheduled classes and was administered by the research team to ensure fidelity in test administration.

Academic achievement. To measure academic achievement, subjects' reading and math scores for the Utah Criterion-Referenced Test were retrieved from the school district. The test was a standardized achievement test that evaluated students' academic knowledge and skills related to specific subject areas, including reading and math. The test was grade-specific; did not contain any bias in regard to age, gender, or ethnicity; and was scored on a 5-point Likert-type scale. The mean scores for math and reading tests ranged from 1 (lowest score) to 5 (highest score).

Table 1. Descriptive statistics on the initial measurement in Year 1 and Year 2, M (SD)

	1-mile run	BMI	Math	Reading
Year 1 (Fall 2009)				
Grade 3	16.11 (3.26)	19.30 (3.56)	2.89 (0.99)	2.77 (0.89)
Grade 4[a]	16.33 (3.34)	19.50 (4.45)	2.55 (1.00)	2.77 (0.91)
Grade 5	15.45 (4.07)	21.15 (4.33)	2.39 (1.15)	2.33 (1.00)
Year 2 (Fall 2010)				
Grade 4[a]	15.81 (3.17)	20.69 (4.37)	2.61 (0.89)	2.93 (0.94)
Grade 5	16.38 (4.20)	21.33 (5.20)	2.38 (1.06)	2.41 (1.00)
Grade 6	13.61 (2.86)	20.83 (4.27)	2.74 (1.00)	2.59 (0.89)

[a]Shows intervention year results; Grade-4 children were in the intervention group in both Year 1 and Year 2.

Data Analysis

Descriptively, the mean differences and SDs (Table 2) and the distribution of the BMI group changes were calculated by year and grade (Table 3). Differences in the 1-mile run and math/reading scores were calculated by subtracting the August from the May measure in each academic year. These differences were the outcomes in the analyses.

For analyses examining changes in cardiorespiratory fitness, math and reading scores, mixed models with ANCOVA were used to allow for correlation of changes over the two repeat occasions. Adjusted means by year and grade were generated, using the covariates gender and age (centered on the mean age in the student's grade to preserve the meaning of grade). Year and grade together determined whether the mean change was associated with the intervention or comparison condition. Because of the "crossover" for those originally in Grade 4 (intervention then nonintervention), the calculation of the net difference attributable to the intervention (correcting for the natural developmental trend from those originally in Grade 5) involves reversing the direction of the developmental trend for those originally in Grade 5.

Finally, descriptive changes in BMI category are presented in Table 3. Chi-square tests were used to determine the BMI group changes over time. Analyses were done using SAS, version 9.3.

Results

Only children with baseline measures were included (Table 1). Approximately 73% of children received free lunch. The final samples included 208 children (121 boys, 87 girls; $M_{age}=10.32$, $SD=0.91$) in Year 1 and 165 children (97 boys, 68 girls; $M_{age}=10.28$, $SD=0.90$) in Year 2. The attrition was due to the mobility of participants and other uncontrollable reasons. Descriptive results are presented in Table 1.

Intervention Effect

The data revealed differences between intervention and comparison groups in difference scores on the 1-mile run

Table 2. Descriptive statistics on the actual difference scores in Year 1 and Year 2

	Year 1 (*n*=208)		Year 2 (*n*=165)	
	Grade	M (SD)	Grade	M (SD)
1-mile run	3	−0.08 (1.69)	4[a]	−1.79 (1.72)
	4[a]	−1.70 (3.30)	5	−1.22 (2.94)
	5	−0.38 (2.37)	6	−0.31 (1.23)
Math	3	0.31 (0.75)	4[a]	0.72 (0.62)
	4[a]	0.68 (0.74)	5	0.51 (0.93)
	5	0.09 (0.87)	6	0.27 (0.82)
Reading	3	0.12 (0.72)	4[a]	0.06 (0.66)
	4[a]	0.15 (0.65)	5	0.06 (0.71)
	5	−0.10 (0.74)	6	0.14 (0.73)

[a]Shows intervention year results; Grade-4 children were in the intervention group in both Year 1 and Year 2.

Table 3. Change in BMI category in Year 1 and in Year 2 by original grade level, *n* (row %)

	BMI transitions in four categories				
	HFZ → NI	NI → NI	HFZ → HFZ	NI → HFZ	Total
Year 1					
Grade 3	5 (7.7)	23 (35.4)	37 (56.9)	0 (0)	65
Grade 4[a]	7 (8.2)	26 (30.6)	51 (60.0)	1 (1.2)	85
Grade 5	0 (0)	35 (60.3)	22 (37.9)	1 (1.7)	58
Total	12	84	110	2	208
Year 2					
Grade 4[a]	2 (3.77)	17 (32.08)	29 (54.72)	5 (9.43)	53
Grade 5	4 (5.88)	26 (38.24)	36 (52.94)	2 (2.94)	68
Grade 6	6 (13.64)	18 (40.91)	20 (45.45)	0 (0)	44
Total	12	61	85	7	165

Note: For Year 1, to calculate the χ^2, Grades 3 and 5 were pooled and also the categories of HFZ→ HFZ and NI → HFZ, resulting in a 2 × 3 table having 2 df; $\chi^2(2)=6.6$, $p=0.037$. For Year 2, to calculate the χ^2, Grades 3 and 5 were pooled and also the categories HFZ → NI with NI → NI, and the categories HFZ→ HFZ with NI → HFZ, resulting in a 2 × 2 table having 1 df; $\chi^2(1)=2.2$, $p=0.135$.
[a]Shows results for intervention year
HFZ, healthy fitness zone; NI, needing improvement

and math scores in Year 1 and Year 2, respectively (Table 4). Specifically, for the 1-mile run, intervention children (Grade 4) had greater improvement than comparison children (Grades 3 and 5) in Year 1, effect estimate= −1.67, $p<0.01$. That is, intervention children had a greater decrease in time to complete the 1-mile run (8.2%) than comparison children.

In Year 2, intervention children (Grade 4) demonstrated greater improvement in fitness than Grade-6 students in the comparison group; effect estimate = −1.79, $p<0.01$. Specifically, intervention children had a greater improvement in the 1-mile run (7.8%) than Grade-6 students. After combining the estimates across years, the pooled intervention effect was −1.50 for the 1-mile run.

Similarly, the pooled exercise program effect for the math difference score was 0.62 based on the estimates in Table 4. In particular, intervention children displayed more improvement on math than did comparison children in Year 1 (19.11%) and Year 2 (10.95%). However, intervention and comparison children did not differ on reading scores in each year.

A comparison of the difference scores in Year 1 and Year 2 revealed net differences in the intervention versus comparison scores on only the 1-mile run for Grade 3 ($p=0.009$). In addition, the children's four BMI group changes differed ($\chi^2_{(2)}=6.6$, $p=0.037$) only for the first year of intervention (Grade 4; Table 3), with a higher percentage of the intervention group remaining in the healthy fitness zone (61% for Grade 4 vs 48% for Grades 3 and 5). In Year 2, comparing the BMI group changes for those originally in Grade 3 to the others, a similar estimate of the difference in the percentages in the "good" or "best" categories was observed (64% for Grade 4 vs 52% for Grades 5 and 6), but the smaller sample size led to $p=0.135$.

Discussion

The present study is the first, to our knowledge, of the impact of an exergaming-based intervention on urban Latino children's physical fitness and academic achievement. Consistent with other school-based intervention studies,[28,29] an exergaming-based intervention was found to have an effect on children's cardiorespiratory fitness over time. Specifically, children participating in 90 minutes/week of structured DDR-based exercise at school demonstrated greater improvement than comparison children on a 1-mile run test across time.

Additionally, the intervention program led to a carryover effect on 4th-grade children placed in the intervention group in Year 1. Other research suggests that short-term exergaming could capture and maintain children's interest and promote a health-enhancing level of fitness in lab settings.[23,30] The current study provided empirical support for using exergaming-based exercise to improve children's cardiorespiratory fitness over time in a school setting.

The findings echo the study by Treviño et al.[29] in this area of inquiry. Specifically, when implementing the Bienestar school-based intervention with predominantly urban Latino children, Treviño et al.[29] found that cardiorespiratory fitness as measured by the step test increased in intervention children and decreased in control children. The current data suggest that school-based interventions with DDR embedded have great potential to benefit urban Latino children's cardiorespiratory fitness if they previously had no structured physical education or physical activity programs at school. In addition, an exergaming program may be very useful to augment current physical education curricula and increase daily physical activity in schools.

Table 4. Adjusted mean differences from August to May, by original grade and year

	Year 1[a] Diff (SE)	Year 2 Diff (SE)	Trend Exercise-Comp (net)	p-value
1-mile run				
Grade 3	−0.084 (0.307)$_a$	−1.790 (0.340)$_b$	−1.777 (0.671)	0.009
Grade 4[b]	−1.67 (0.268)$_b$	−1.214 (0.230)	−0.409 (0.635)	0.520
Grade 5	−0.379 (0.324)$_a$	−0.307 (0.372)$_a$	0.072 (0.493)	
Math score				
Grade 3	0.325 (0.099)$_a$	0.735 (0.109)$_b$	0.226 (0.216)	0.295
Grade 4	0.673 (0.086)$_b$	0.497 (0.096)	0.360 (0.204)	0.079
Grade 5	0.081 (0.104)$_a$	0.265 (0.120)$_a$	0.184 (0.159)	
Reading score				
Grade 3	0.120 (0.087)	0.054 (0.097)	−0.307 (0.191)	0.109
Grade 4	0.155 (0.076)	0.060 (0.085)	0.335 (0.181)	0.064
Grade 5	−0.103 (0.092)	0.138 (0.106)	0.241 (0.140)	

Note: Net difference between intervention year and comparison year (for those who had an intervention year). Those originally in Grade 5 had no intervention, and the difference in the outcome between Grade 6 and Grade 5 is taken as the natural developmental trend used to calculate the net difference between the intervention and the comparison, correcting for the estimated developmental trend.

[a]Subscript lowercase letters *a* and *b* indicate that there is a variation in the difference scores between the groups within Year 1 or Year 2, $p<0.05$.

[b]Note that Year 1 is the intervention year for those in Grade 4 and in Year 2 the students are in a non-intervention year. In calculating the net effect, the developmental trend must be reversed. For example, for the 1-mile run, the intervention net effect must be estimated [1.67− (−1.214)] − [−0.379 − (−0.307)].

Diff, difference scores; Exercise-Comp, intervention vs comparison

Although the intervention led to improvements in cardiorespiratory fitness, there was not an effect on children's BMI group changes across time, with the exception of intervention children (Grade 4) in Year 1 who had a higher percentage remaining in the healthy fitness zone than comparison children (Grades 3 and 5). Few studies have investigated the effects of exergaming on body composition among different samples. For example, Graves et al.[31] conducted a 12-week exergaming intervention with young children (aged 8–10 years), but they did not find differences in body fat between intervention and control groups after the intervention.

In contrast, Maddison et al.[20] implemented a 24-week exergaming intervention with 322 overweight and obese children aged 10–14 years. At the end of the intervention, changes in BMI increased from baseline to post-test in control children but remained the same for intervention children. Also, intervention children showed a reduction in body fat. Although the current study did not find a strong effect for changes in body composition, the authors speculate that a plausible explanation is that a different targeted population was used than that in the Maddison et al. study.

An individual's BMI is affected by numerous factors, including genetic heritage, cultural and environmental influences, and nutrition, especially for children from Latino immigrant families.[32,33] Hence, the current authors recommend that research take into account multiple factors (e.g., acculturation, birthplace, immigration status, eating behaviors) when examining the determinants of overweight and obesity in urban Latino children. More long-term exergaming interventions may be needed to alter body composition trajectories in children. The present findings regarding BMI are consistent with a large RCT known as the Trial of Activity for Adolescent Girls that indicated no BMI changes over 3 years[34] and no change in percentage of body fat over 8 months.[29]

The second research hypothesis focused on the effect of the exergaming-based exercise program on children's math and reading scores over time. Although both intervention and comparison children improved math performance over time, intervention children had greater improvement on math scores than comparison children in Year 1 and Year 2. Again, there was a carryover effect for the Grade-4 children in Year 1. Context-specific exergaming may have the potential to influence specific brain activity through timing and pattern-reading, which have been linked to increases in math achievement in normal and attention deficit/hyperactivity disorder populations.[8]

There also was a trend for increased reading scores in the intervention groups over time. It is plausible that children performed better in reading and math as they grew up and obtained more instruction. Thus, more comprehensive and long-term studies using innovative exergaming-based exercise programs among Latino children are warranted. Results supported previous research indicating that increasing physical activity opportunities during school either enhanced academic achievement or did not adversely affect academic achievement.[10,28]

Limitations

Study limitations should be identified to direct future research. First, only the Grade-4 children were placed in the intervention group across the 2 years, whereas the children in other grades were placed in the comparison group. This design was necessary because of school schedule conflicts, space limitations, and resistance from a few classroom teachers. Therefore, it was not possible to investigate the potential confounding effect that age and maturation and selection bias had on the outcome variables.

Second, the present study included only one DDR as half of the implemented exercise program, and children's attention span and interest led to a decrease in their motivation to play only one game. Third, participants were recruited from only one predominantly Latino urban school that offered no physical education or any other physical activity programs, which limits the generalizability of the research findings. Additionally, in a crossover design, order effects (carryover) and period effects can confound the estimate of an intervention effect.

Order effects may affect the comparison Year-2 result of −1.21 for the 1-mile run. For the 1-mile run for those originally in Grade 4, the estimate effect may be partially due to the fact that children played DDR in Year 1. The summer interlude (wash-out) may have been insufficient to remove the effect of having had the intervention in the previous year. The bigger intervention effects in Year 2 for the 1-mile run may have been a period effect, relating to the modifications to the protocol, and teachers in the new Grade 4 being sensitized to the intervention. Finally, the students originally in Grade 5 who were never in the exercise program constituted a control for natural developmental trend, but the development of a child aged 12–13 years may not be an appropriate control for that of a student who is 1–2 years younger.

Conclusion and Public Health Implications

Findings of this study add to the growing body of literature for the effects of DDR-based exercise on urban Latino children's physical fitness and academic achievement, and they offer directions for future studies. Specifically, future studies should adopt RCTs by integrating the exergaming-based exercise program into schools' curricula. Future research should also integrate a variety of exergaming (e.g., Wii games, Kinect games) to allow children multiple choices during exercise, which could promote autonomy and sustained motivation for participation. In addition, to generalize the research findings to large and diverse populations, the exergaming interventions should be implemented at multiple school sites with school as the experimental unit.

Overall, participation in the exergaming-based program demonstrated a long-term, positive effect on children's cardiorespiratory fitness and math scores. These findings can help inform local policy decisions regarding school-based physical activity interventions, especially policies that can promote in-school physical activity participation among urban Latino children. Educators may integrate exergaming at urban schools to achieve the goals of promoting a physically active lifestyle, helping reduce the prevalence of obesity, and enhancing academic success in urban Latino children.

Publication of this article was supported by the Robert Wood Johnson Foundation.

This study was funded by the Robert Wood Johnson Foundation through its national program, *Salud America*! The RWJF Research Network to Prevent Obesity Among Latino Children (www.salud-america.org). *Salud America!*, led by the Institute for Health Promotion Research at The University of Texas Health Science Center at San Antonio, Texas, unites Latino researchers and advocates seeking environmental and policy solutions to the epidemic.

No financial disclosures were reported by the authors of this paper.

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