GAMES FOR HEALTH JOURNAL: Research, Development, and Clinical Applications
Volume 1, Number 1, 2012

DOI: 10.1089/g4h.2011.0005

Pilot Study of an Active Screen Time Game Correlates with Improved Physical Fitness in Minority Elementary School Youth

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Abstract

Objective: The aim of our feasibility study was to examine the acceptability and utility of "Dance Dance Revolution" (DDR) (Konami of America, Redwood City, CA)) to increase physical fitness in 8–11-year-old black and Hispanic youth.
Subjects and Methods: Twenty-eight 4th and 5th grade children attending an afterschool program participated. Outcomes included physical activity, physical fitness, use of home DDR, survey of safety and acceptability, anthropometrics, and fasting metabolic profile measured at baseline, 12 weeks, and 30 weeks.
Results: At 12 weeks, physical fitness (maximum O_2 uptake [VO_2max]) increased by 4.9 ± 9.9 percent and was sustained through 30 weeks, when the VO_2max was 105.0 ± 9.9 percent (range, 93.0–133.9 percent) of baseline values. Absolute VO_2max increased by 2.97 ± 4.99 mL/kg/minute (95% confidence interval 0.75–5.19, $P = 0.013$). Participants maintained an average of 1.12 hours/day of increased movement to music. Trends suggested increased total moderate–vigorous physical activity, decreased light activity, and a modest increase in sedentary screen time. There were no significant changes in body mass index, fasting lipids, or glucose. Participants and parents approved of the activity.
Conclusion: DDR appears feasible and acceptable to minority youth. DDR may increase moderate–vigorous physical activity and improve physical fitness in at-risk populations.

Introduction

Body mass index (BMI) has been increasing in both preschool[1] and school-age[2,3] youth. Pediatric obesity is associated with the development of cardiac, endocrine, musculoskeletal, psychiatric, and psychosocial maladies.[4–7] Obesity disproportionately impacts minorities with one in five black or Hispanic youth being obese.[8,9]

Youth are consuming calorie-dense diets[10,11] coupled with decreased physical activity in the context of increased sedentary screen time (SST) such as television and videogames. As for interventions, reducing SST and increasing physical activity (PA) may have a stronger impact on reducing BMI percentile than reducing calorie consumption in young school-age youth.[12] Furthermore, improved physical fitness may have cardiac and endocrine benefits beyond those achieved with diets alone.[13–15] PA begins to decrease in children by 9 years of age.[16] Accordingly, promotion of increased PA as a primary component in the prevention and treatment of pediatric obesity may significantly reduce obesity-associated morbidity.

Daily physical education programs in public schools have declined considerably in the last 20 years.[17] Minimal progress has been made since the Surgeon General's 2001 Call to Action recommending that all pre-kindergarten through 12th grade children have access to quality daily physical education classes and that additional daily recess be made available for elementary schoolchildren.[18] Many states promote "goals" for minutes of PA each week, but few mandate minimum standards consistent with guidelines of the National Association for Sport and Physical Education.[19]

Home PA programs are an alternative worth considering because (1) most of a child's non-school sedentary hours are spent at home, (2) SST is the single largest component related to home sedentary time, and (3) children usually have more flexibility in choice of activities at home compared with school.[20,21] Children may gain weight faster during the summer months when school is out of session and they are at home.[22,23] In the United States, this effect was most prominent among black and Hispanic children and those children who were already overweight. Interventions delivered at home may displace current

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media that appears to promote childhood obesity.[24] To foster broad, enduring changes in behavior, interventions should be applicable to the school and home environments.

The primary aim of this feasibility study was to test the acceptability of an active videogame, "Dance Dance Revolution" (DDR) (Konami of America, Redwood City, CA)), as a physical activity for black and Hispanic 8–11-year-old children. This feasibility study also explored the impact of DDR on outcomes such as lifestyle behaviors, metabolic parameters, and physical fitness.

Subjects and Methods

Participants and setting

The Institutional Review Board of the University of North Carolina at Chapel Hill approved the study protocol. The study population was recruited from a convenience sample of 34 children attending an afterschool program, which met 4 days per week. Parents signed informed consent, and all children signed an assent prior to participation. Inclusion criteria merely required that participants attend the afterschool program. Participants were excluded for physical illness that would preclude vigorous PA or sensitivity to exposure to visual stimuli (e.g., photosensitive seizures). Most Hispanic youth in the study were non-native English speakers. Spanish forms were provided to all who requested them, and a translator was available for the informational meeting and parental consent. Parents received a $10 gift card for completing forms at baseline and 12 weeks.

Intervention

The children in the study had access to DDR up to 3 days/week for approximately 30 minutes during after school and unlimited access at home. The 30-week DDR intervention began in September and concluded in April. Participants did not have prior experience with DDR. Each child received a Playstation® 2 (PS2) game console (Sony Corporation of America, New York, NY), "DDR Extreme" game (Konami of America), a 8MB memory module, and two dance mats. The memory module's preprogrammed game settings facilitated early success: Lowest difficulty setting, all songs play to completion regardless of performance (no failing), and derogatory audio commentary disabled (no booing). The memory module allowed longitudinal tracking of several behaviors: (1) How many different songs were played; (2) difficulty level of each song played; (3) letter and numerical scores; (4) were songs played with someone else (social/competitive); (5) were players using two mats as one (highly skilled); (6) frequency of play by date; and (7) use of the PS2 to play other games.

To play the game, the participant steps on a dance pad with four directional arrows (up, down, left, right) in a pattern that corresponds to a visual display of scrolling arrows on a television screen. The arrow pattern is synchronized to music, which provides an auditory guide. The overall difficulty of a given song is a function of the number and complexity of the arrows. The lowest difficulty level, "Beginner," utilizes a model player in the background that demonstrates which arrow to hit during game play. Higher levels are "Light," "Standard," "Heavy," and "Challenge." These feature music videos, animations, or static backgrounds. Scoring on all levels depends on a player's ability to match each step. A perfect match received the highest score, "Perfect." Lower accuracy gives progressively lower scores of "Great," "Good," "Almost," and "Miss." Upon completion of a song, the player receives an overall letter grade ranging from AAA (100% Perfect) down to E (lost all energy). The game reports real-time statistics such as steps at each accuracy level.

The memory module allows tracking of performance for up to 120 consecutive days. We instructed participants and families to reserve the Player 1 slot for study participants. Memory cards were collected at 6 weeks and 12 weeks to gather behavioral data.

Outcome measures

Physical examination. All participants underwent a history and physical exam to screen for significant impairments. Vital signs included resting blood pressure and pulse from an Omron (Bannockburn, IL) HEM-637 blood pressure monitor applied to the wrist.

Anthropometrics. All measurements were collected at the afterschool program. Standing height was measured with a Tanita (Tokyo, Japan) Accustat portable stadiometer with participants in their bare feet. Weight, body fat percentage, and calculated BMI were measured with a commercial bioelectric impedance scale (model TBF-300A, Tanita) with participants in light clothing. Bioimpedance is a validated method of assessing body fat in youth.[25,26] BMI was verified via Epi Info software version 3.3.2,[27] which also provided BMI percentiles and *z*-scores.

Blood sampling. Fasting blood samples were collected at baseline and 12 and 30 weeks and analyzed for total cholesterol, low-density lipoprotein, high-density lipoprotein, triglycerides, and glucose by a CardioChek® PA (Polymer Technology Systems, Indianapolis, IN) device.

Physical activity. PA was monitored with a parent report developed by Dennison et al.[28] that separates daily physical and sedentary behaviors into seven categories: sleeping, watching TV, playing video or computer games, moving or dancing to music, light activity (puzzles, arts, crafts, reading), moderate activity (walking), and active play (running, jumping, biking). The Dennison form was modified to categorize DDR as exclusively "moving to music" and to exclude DDR from "videogames." Parents record the hours of each activity for Saturday, Sunday, and the weekday average.

Physical fitness. The 20-meter shuttle run test (20mSRT) evaluated physical fitness at baseline and 12 and 30 weeks. The 20mSRT involves moving between parallel lines 20 meters apart in time to an audible "beep." The initial interval is equivalent to an 8 km/hour pace, which increases by 0.5 km/hour each minute. Aside from three practice sessions a week prior to baseline data collection, participants had no prior exposure to the 20mSRT. A regression formula[29] calculates maximum O_2 uptake (VO_2max) based on the highest stage reached during the test. The 20mSRT is a valid and reliable method of calculating aerobic fitness in youth.[30]

Safety and tolerability. Separate safety and satisfaction questionnaires were given to parent (17 items) and child (11

items). The forms queried characteristics of DDR, how it was played, who played, and the quality of play. The parent form has additional queries such as when a child stopped being interested in DDR, how disruptive the game was, and whether the parent would recommend it to others.

Data management and statistical analysis

Data were entered into Microsoft (Redmond, WA) Access and then converted to Microsoft Excel files. Descriptive and exploratory inferential statistics were calculated and presented via GraphPad (San Diego, CA) Prism version 5.04. Each child served as his or her own control in comparing baseline with outcomes at week 12 and week 30. Outcomes were analyzed with repeated-measures analysis of variance and paired *t* test.

Results

Thirty-four youth enrolled, with 28 completing at least one post-baseline assessment (Table 1). Approximately 43% of the participants were Hispanic children with limited English proficiency. Most of the children had daily access to media in the bedroom: 71% had a television, and 61% had a DVD/VCR. Nearly all households had at least one adult who was employed full-time, yet only one household (4%) earned more than $60,000 per year.

Table 2 summarizes vital signs, fasting lipid profiles, anthropometrics, and body composition throughout the study. Youth gained stature faster than weight, resulting in a decline in BMI *z*-score. Blood pressure and heart rate exhibited minimal changes and were within normal limits. Overall, metabolic outcomes (fasting lipids, glucose) were unchanged based on repeated-measures analysis of variance.

Using the Dennison form, parents provided a glimpse into how these youth spent their days. Baseline data suggest these children were averaging more than 3 hours/day of active play on weekdays and more than 4 hours on Saturday. Figure 1 reveals a pattern of relatively stable PA across active play, light activity, and SST from baseline to 12 weeks. Yet, there is a noticeable increase in "Moving to Music" among study participants reported at week 12, which was maintained through week 30 (Fig. 2). Parents reported a 67 percent increase (0.89 hours) in activity to music on weekdays, 81 percent (1.33 hours) on Saturdays, and 74 percent (1.05 hours) on Sundays. If this change represented DDR utilization, then participants were averaging 1.12 ± 0.30 hours/day of DDR. Memory card data revealed 19 youth were playing DDR more than 1 hour/day at home, had become accomplished players at more than 30 different songs, or both within 12 weeks. Memory card data indicated that participants did not use the provided PS2 for sedentary games at any time.

At 12 weeks, performance in the 20mSRT corresponded with a 6.2 ± 9.6 percent improvement in VO_2max compared with baseline among high home use subjects ($n = 19$). If all participants ($n = 22$) are included at week 12, the mean VO_2max improvement falls to 4.9 ± 9.9 percent (Fig. 3). Five children improved VO_2max by more than 10 percent (range, 11.5–30.9 percent). Among the 23 participants with week 30 data, 15 (65.2%) improved, two maintained, and six became less fit. The numerical baseline VO_2max of 55.18 ± 6.98 mL/kg/minute increased to 57.95 ± 7.31 mL/kg/minute by week 30. The mean improvement in VO_2max of 2.97 ± 4.99 mL/kg/minute was statistically significant by paired *t* test (95% confidence interval 0.75–5.19, $P = 0.013$).

Tolerability and safety outcomes were collected at weeks 12 and 30. Figure 4 summarizes primary findings from week 12. Although the majority continued to play at 12 weeks, 42%

Table 1. Child and Household Demographics

Demographic	n	*Percent*
Children		
Mean ± SD (years)	9.9 ± 0.7	
Male	18	64.3
Black	16	57.2
Hispanic/Latino	12	42.8
School-age sibling at home	25	89.3
TV in bedroom	20	71.4
DVD/VCR in bedroom	17	60.7
Household		
2+ adults	19	67.8
High school graduate	19	67.8
College graduate	1	3.6
1+ employed full-time	26	92.8
Family income		
< $20,000	11	39.2
< $40,000	20	71.4
> $60,000	1	3.6
Family car	28	100.0
3+ Televisions	22	78.5
2+ DVD players	15	53.6
2+ VCRs	13	46.4

Table 2. Summary of Anthropometrics and Fasting Laboratory Results

	Baseline	*12 weeks*	*30 weeks*
n	28	25	23
Weight (kg)	40.3 ± 10.8	41.7 ± 11.2	43.2 ± 11.1
Height (cm)	141.6 ± 6.7	144.0 ± 7.1	147.6 ± 7.4
BMI (kg/m^2)	19.8 ± 3.9	19.9 ± 3.9	19.6 ± 3.5
BMI percentile	68.4 ± 28.7	67.1 ± 30.6	64.5 ± 28.8
BMI percentile median/75th	77.5/95	77/94.5	67/92
BMI *z*-score	0.71 ± 1.05	0.66 ± 1.10	0.55 ± 1.00
Heart rate (bpm)	86 ± 11	NA	86 ± 15
Blood pressure (mm Hg)			
Systolic	112 ± 10	NA	113 ± 9
Diastolic	70 ± 8	NA	72 ± 7
Fasting lab values	27	27	20
Glucose (mg/dL)	84 ± 7	88 ± 8	78 ± 5
Total cholesterol (mg/dL)	162 ± 34	163 ± 36	134 ± 32
LDL (mg/dL)	99 ± 31	98 ± 29	NA
HDL (mg/dL)	61 ± 18	59 ± 18	48 ± 24
Triglycerides (mg/dL)	89 ± 41	102 ± 44	99 ± 40
Total cholesterol/HDL ratio	2.9 ± 0.9	3.0 ± 0.8	3.1 ± 0.8

All data are reported as mean ± SD values except body mass index (BMI) percentile median and highest quartile.

HDL, high-density lipoprotein; LDL, low-density lipoprotein; NA, not available.

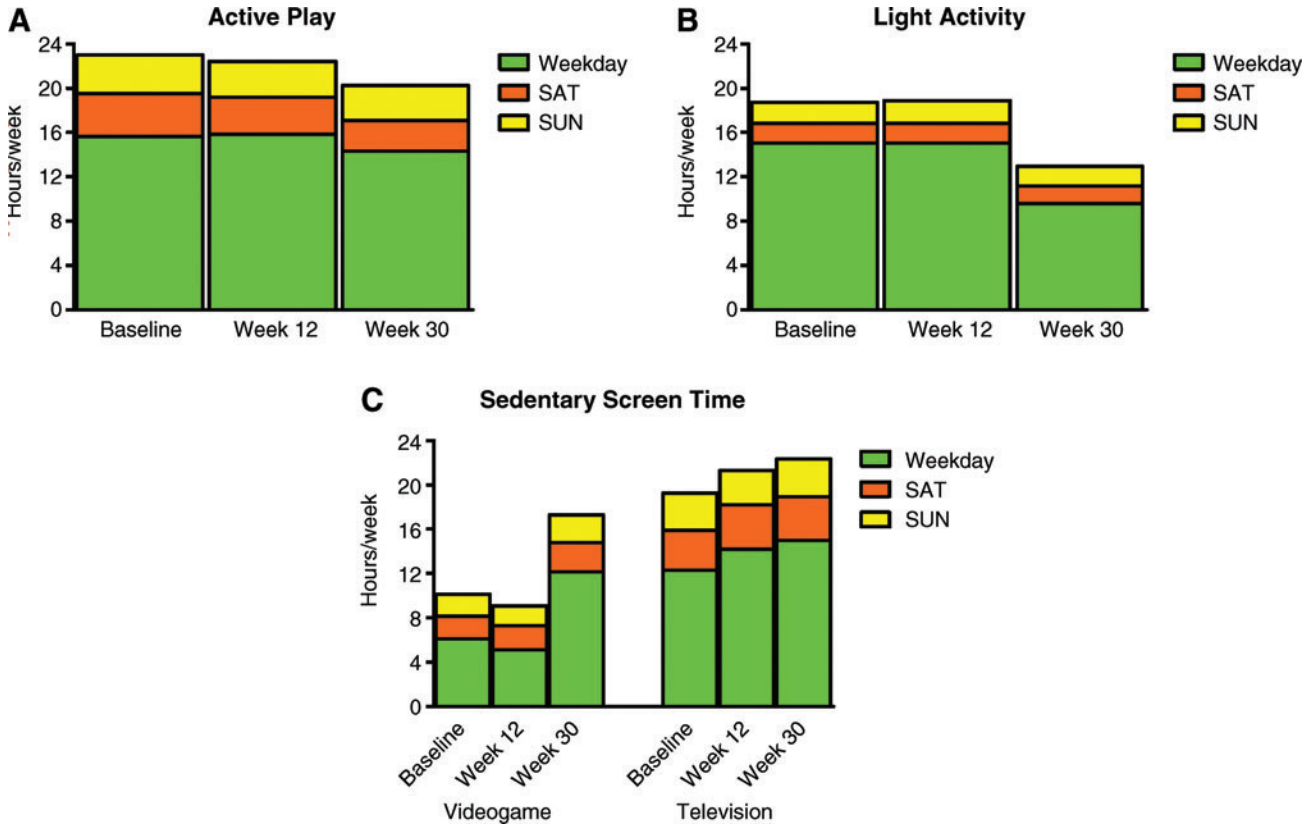

FIG. 1. Distribution of active and sedentary behaviors. (**A**) Active behaviors include running, jumping, and biking and are typically outdoors. (**B**) Light activity would include behaviors such as puzzles, arts and crafts, and reading. (**C**) Sedentary screen time is behavior in front of monitors or televisions, such as TV viewing, movies, and sedentary videogames. "Dance Dance Revolution" is excluded from SST. Color images available online at www.liebertonline.com/g4h

had lost interest in the activity within 3 months. Parents and participants enjoyed the activity and reported few problems with DDR in the home. Parental comments on DDR were uniformly positive: "displaced TV time," "good activity during inclement weather," "occupies the child," "family activity," "good exercise," and "convenient." Comparable child comments included "fun," "different," "social," "good exercise," and "helped with weight loss." Children typically reported less parental DDR play than the parents. Some parents acknowledged playing only when the child was not around. Injuries were mild contusions and sprains that did not impact ability or motivation to play.

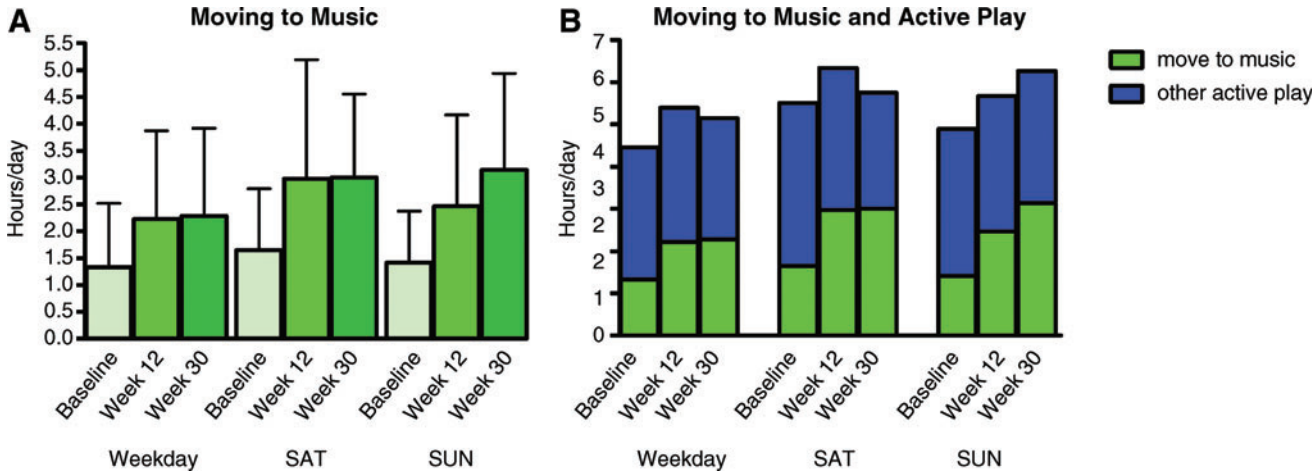

FIG. 2. Parent report of (**A**) daily physical activity to music and (**B**) combined physical activity to music and active play. Results are included only for participants with data available for all three assessments. Data are presented as group means and standard deviations. Color images available online at www.liebertonline.com/g4h

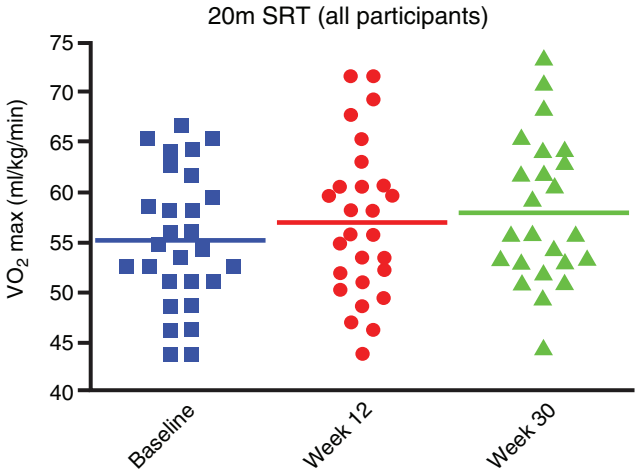

FIG. 3. Physical fitness performance on the 20-meter shuttle run test (20mSRT). VO_2max, maximum O_2 uptake. Color images available online at www.liebertonline.com/g4h

Discussion

This feasibility study demonstrated that minority youth from lower socioeconomic backgrounds found DDR to be an appealing option for PA during an afterschool program and leisure time at home. Furthermore, participation in this study coincided with a statistically significant improvement in physical fitness. Children's affinity for dance activity is not novel to our study,[31] but the intensity and enduring character of this new media experiment were notable. Based on the Dennison form, memory card data, and parent surveys, most of these children added several hours of DDR to their weekly home PA for nearly 7 months. These results are superior to a study of 30 overweight pubescent youth where home DDR use peaked at initiation (90 minutes/day), but only two subjects were playing DDR twice a week by 6 months.[32] In a previous DDR study, there was a significant reduction in SST: -1.3 ± 3.7 hours/day,[33] which was not observed in the current study.

Although it is logical to believe sedentary behaviors are inextricably linked and inversely proportional to active behaviors, the relationship is not consistent across studies.[34–36] Sedentary and active behaviors clearly have an impact on health and fitness, but other factors may have a far greater impact on the distribution of leisure time activity than the interaction between sedentary and active behaviors.[37–39]

One fundamental difference for DDR lies in that it is a PA that requires the use of a television. Yet, there is no guarantee that a child will not displace outdoor play with DDR, thereby sparing some portion of SST. Conceivably, emphasizing activity through game consoles may promote increased participation in sedentary games. Parents reported an increase in "Moving to Music" but no change in total videogame play between baseline and 12 weeks. Yet, parental surveys at 30 weeks revealed an increase in videogame play compared with baseline.

DDR is highly player modifiable and has a variety of settings and modes that can make the game easier or more difficult. After a few months of game play, a child could play a variety of set courses of songs without interruption. These modes significantly increase the challenge and aerobic utility by minimizing interruptions during game play. The flexibility within DDR may facilitate continued play on the basis that reinforcing/rewarding behaviors require an element of choice.[40] Furthermore, the perceived competence and overall enjoyment with mastered songs may increase intrinsic motivation to continue.[41,42]

Our study utilized two strategies associated with positive outcomes in childhood obesity prevention: Participants

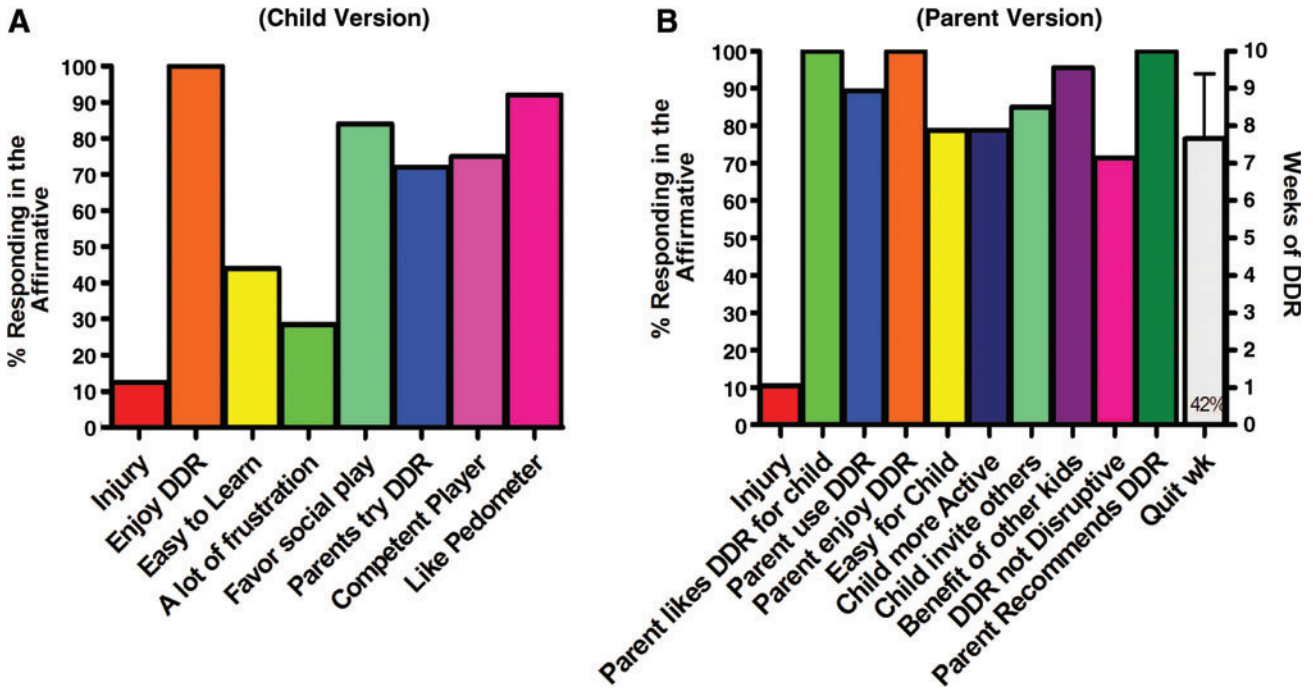

FIG. 4. Week 12 safety and satisfaction surveys of (**A**) child and (**B**) parent. DDR, "Dance Dance Revolution." Color images available online at www.liebertonline.com/g4h

largely controlled their exposure to the intervention, and it did not attempt to directly target multiple behaviors.[43] The impact of DDR is potentially quite significant over time given that as little as a 110–165 kcal flux in daily energy balance[44] or approximately 30–45 minutes of DDR instead of sedentary behavior might be sufficient to prevent obesity in children.

Although this study lacked an objective assessment of PA, the 20mSRT data suggested improved physical fitness. Late prepubescent youth are often at their peak specific VO_2max because peripubescent physical growth tends to outpace fitness improvements.[45,46] Yet, physical fitness in our study improved significantly within the first 12 weeks, with gains maintained through 30 weeks. Other investigators have noted post-intervention improvements within 12 weeks with DDR[47] and 8 weeks with other school-based interventions.[48] The 20mSRT and Leger regression to calculate VO_2max provide reasonable estimates of physical fitness, given that the baseline VO_2max in our study was comparable to cycle ergometer and 20mSRT data from samples of Tanzanian and Swedish youth of similar ages[49] and a U.S. sample of youth on treadmill.[50] Previous DDR studies indicate that it can be comparable to other forms of moderate–vigorous PA, such as tennis or moderate intensity walking,[51,52] and that participants can reach minimum heart rates suggested in the American College of Sports Medicine guidelines for the development of cardiopulmonary fitness.[53] Metabolic parameters did not change, but it is possible for overweight youth to improve physical fitness without notable improvements in fasting lipids or glucose.[54]

As a group of minority youth, one would expect baseline anthropometrics to be above the population median. But it is concerning that the median BMI percentile for the group was 77.5, and a fifth exceeded the 95th percentile. Unfortunately, this is typical for urban American elementary school-children.[55] These children appear to be physically healthy, but anthropometrics reveal the majority to be overweight and that much of that excess mass is body fat. The implications are serious given that pediatricians and parents are unlikely to intervene when kids are gaining insidious body fat without clear indications of negative health outcomes. The future burden of disease for these youth may be significant without early interventions to prevent the development of weight-associated disorders such as type 2 diabetes.[56] Given the disproportionate impact on lower socioeconomic communities and minorities, effective interventions need to be developed and implemented to maintain PA and fitness during early childhood through adolescence.

DDR is one of many emerging active games being explored as alternatives to sedentary behaviors.[57] However, none should be considered substitutes for regular PA occurring within the school curriculum, extracurricular, at home, or in the community. Active games should supplement available resources. DDR may be particularly useful in schools and homes that lack resources for the provision of adequate game equipment or facilities for indoor/outdoor exercise but have existing resources suitable for DDR or similar games.[58,59] Furthermore, it is an activity that can take place without regard to weather, community safety concerns, differences in physical fitness, skill level, or motivation of classroom teachers or parents.[60–62] It is not clear that school-based interventions will be broadly useful for changing health behaviors, but afterschool activity appears to be a prime modifiable factor in the development of obesity.[63,64]

The small sample size and lack of randomization to a control condition are notable limitations in this pilot. Although the use of inferential statistical analysis is appropriate, conclusions about the utility of DDR in improving the physical fitness of youth are limited until replicated in adequately powered, randomized controlled trials. An objective assessment of PA, such as an accelerometer, would clarify the relationship between the intervention and improved physical fitness.[65] Finally, the parental report of PA requires the parents to estimate multiple behaviors they do not directly observe continuously. The impact may be significant because parents tend to underestimate TV viewing if there is a TV in the child's bedroom.[66]

This pilot study suggests DDR is a feasible and acceptable PA that may improve the physical fitness of minority school-age youth. The improvements were correlated with subjective assessments suggestive of increased moderate–vigorous PA, yet coincided with a trend of increased SST. Further studies in well-powered, prospective, randomized controlled trials are necessary to clarify the potential of DDR or other active games to promote PA, displace SST, maintain or improve physical fitness, and positively impact metabolic parameters associated with chronic medical conditions. Future studies should use multiple objective assessments of both PA and physical fitness and explore active game options that are not dependent on commercial game consoles.

Acknowledgments

The authors are extremely grateful to the children, their parents, and administrators (Vanessa Stone, Jean Maness, and Clara Chavez) for their participation in this project. Funding was provided by an unrestricted grant from Getting Kids in Action, a partnership between The University of North Carolina at Chapel Hill and the Gatorade® brand. During the development of this trial, T.C.B. was supported by the Neurodevelopmental Disorders Research Center (grant T32 40197). A.E.M. has received support from Maine Medical Center Research Institute and grant 2008-55215-18837 from the U.S. Departmennt of Agriculture.

Author Disclosure Statement

The authors have no competing interests.

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