Impact of an Active Video Game on Healthy Children's Physical Activity

WHAT'S KNOWN ON THIS SUBJECT: Active video games can enable children under laboratory conditions to participate in moderate, and even vigorous, physical activity. There are inconsistencies in the literature, however, about whether active video games enable children to increase physical activity under more naturalistic circumstances.

WHAT THIS STUDY ADDS: This study tests whether children receiving a new active video game spontaneously engaged in more physical activity, and whether commercially available active video games have a public health benefit. No additional physical activity was detected, suggesting no public health benefit.

abstract

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OBJECTIVE: This naturalistic study tests whether children receiving a new (to them) active video game spontaneously engage in more physical activity than those receiving an inactive video game, and whether the effect would be greater among children in unsafe neighborhoods, who might not be allowed to play outside.

METHODS: Participants were children 9 to 12 years of age, with a BMI >50th percentile, but <99th percentile; none of these children a medical condition that would preclude physical activity or playing video games. A randomized clinical trial assigned children to receiving 2 active or 2 inactive video games, the peripherals necessary to run the games, and a Wii console. Physical activity was monitored by using accelerometers for 5 weeks over the course of a 13-week experiment. Neighborhood safety was assessed with a 12 item validated questionnaire.

RESULTS: There was no evidence that children receiving the active video games were more active in general, or at anytime, than children receiving the inactive video games. The outcomes were not moderated by parent perceived neighborhood safety, child BMI *z* score, or other demographic characteristics.

CONCLUSIONS: These results provide no reason to believe that simply acquiring an active video game under naturalistic circumstances provides a public health benefit to children. *Pediatrics* 2012;129:e636–e642

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KEY WORDS
exergames, Wii

ABBREVIATIONS
CNRC—Children's Nutrition Research Center
PA—physical activity

This project was conceptualized and managed by a multidisciplinary team. All the coauthors made substantial contributions to this manuscript. Dr Baranowski, a psychologist, helped conceive the study, chaired the weekly meeting of coinvestigators that reviewed progress, and wrote the initial draft. Ms Abdelsamad, research coordinator, had day-to-day responsibility for conduct of the study with participants, including data collection. Ms Baranowski, a dietitian, supervised the conduct of the study and maintained correspondence with external agencies (eg, the institutional review board). Dr O'Connor, a pediatrician, and Dr Thompson, a qualitative research specialist, participated in the weekly meeting of coinvestigators, and made many valuable contributions. Dr Barnett, an exercise physiologist, participated in the conceptualization of the study and wrote the grant application. Dr Cerin, a statistician and psychologist, participated in the conceptualization of the study, reviewed and edited the grant application, and intensively reviewed the data analyses. Dr Chen, a psychometrician and statistician, conducted all data analyses. All the authors critically reviewed early drafts of the manuscript and provided final review of the manuscript to be published. All the authors take responsibility for the content of this manuscript.

The contents of this publication do not necessarily reflect the views or policies of the USDA, nor does mention of trade names, commercial products, or organizations imply endorsement from the US government.

This trial has been registered at www.clinicaltrials.gov (identifier NCT01024153).

www.pediatrics.org/cgi/doi/10.1542/peds.2011-2050

doi:10.1542/peds.2011-2050

Accepted for publication Nov 9, 2011

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PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

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Although young children get reasonable amounts of physical activity (PA), levels of PA decline throughout childhood,[1] dropping well below recommended levels.[2–4] The risk of being an obese adult from being obese as a child increases enormously at 10 years of age,[5] suggesting that 10 years of age is a critical period for increasing PA to prevent child and adult obesity.

Laboratory studies have demonstrated that the right person can engage in moderate (3+ metabolic equivalents),[6,7] and even vigorous (6+ metabolic equivalents),[8] levels of PA with active video games. Among studies under more naturalistic circumstances, 2 studies showed some increase in PA from active video games,[9,10] one showed a small change in adiposity, but not activity,[11] and a fourth showed no changes.[12] An experimental design with randomization is needed, addressing the duration of how long increased PA was sustained with the use of objective measures.[13]

The present randomized trial assessed whether 9- to 12-year-old children would increase their level of PA, measured with accelerometry, with the acquisition of a new (to them) Wii console and a choice of 2 (of 5) active video games with all necessary peripherals, compared with children receiving a new Wii console and choice of 2 (out of 5) inactive video games and all the necessary peripherals. The hypothesis was that children receiving the active video games would increase their levels of PA.

METHODS

Participants

The inclusionary criteria were an age of 9 to 12 years; BMI between the 50th and 99th percentiles (at risk for adult obesity); ability of the child and family to speak, understand, read, and write English (because of the limits of the available games and the parental reporting of some data); permission by the parent allowing the child to play the provided video game (active or inactive); and the presence of a television in the household to which the Wii console could be attached. Children were excluded if they had a medical problem (including epileptic seizures) that would prevent them from being physically active or playing video games; if they had a family history of epileptic seizures (because of the risk of seizures from video screens)[14]; if they already had a Wii game console in the home (and, thereby, not being "new" to the child); if they did not provide at least 5 of 7 complete days of accelerometry data at baseline (a "break-in period" because of concerns about difficulties in obtaining 5 weeks of accelerometry data over the course of the study); and if they lived beyond 15 miles from the Children's Nutrition Research Center (CNRC) (because of concerns about getting the family to data collections and delivering the Wii consoles on several occasions).

Design

Children were randomly assigned, after baseline assessment, to treatment or control groups. Random assignment was conducted by using a random number generator (generated by the statistician) and randomly allocating sequential positions in the enrollment book to treatment or control conditions. Children were entered sequentially as they met inclusionary criteria. The project manager assigned participants to sequential positions and informed staff of conditions.

All children were provided Wii game consoles. Children in the treatment group were offered a selection of one active, and the control group of one inactive, video game at the beginning of week 1 and another at beginning of week 7. PA was monitored by using accelerometry at baseline, and weeks 1, 6, 7, and 12. Height, weight, and self-reported measures were obtained at baseline, between weeks 6 and 7 (midassessment), and after week 12 (postassessment).

Intervention and Control Conditions

Each participating child was provided a Wii console. Self-determination theory posits that providing choice enhances intrinsic motivation to perform a behavior.[15] The treatment group was given a choice of 1 active video game (from among 5; see Table 1) with all necessary peripherals to play that game at the beginning of week 1 and of another at the beginning of week 7. To remain true to naturalistic circumstances, no prescription was provided on when or how to play the video games, and no prohibitions were provided against purchasing

TABLE 1 Listing of the 5 Offered Active and Inactive Games for the Wii Console, and the Peripherals Provided Corresponding to Each Game Selected

Video Games Offered		Corresponding Peripherals Provided With Game
Active		
1.	Active Life-Extreme Challenge	Mat controller, remote controller, and Nunchuk controller
2.	EA Sports Active	Resistance band, leg strap, remote controller, and Nunchuk controller
3.	Dance DanceRevolution-Hottest Party 3	Mat controller, remote controller, and Nunchuk controller
4.	Wii Fit Plus	Balance board, remote controller, and Nunchuk controller
5.	Wii Sports	Remote controller and Nunchuk controller
Inactive		
1.	Disney Sing It-Pop Hits	Microphone, remote controller. and Nunchuk controller
2.	Madden NFL 10	Remote controller and Nunchuk controller
3.	Mario Kart Wii	Wheel, remote controller. and Nunchuk controller
4.	New Super Mario Bros. Wii	Remote controller and Nunchuk controller
5.	Super Mario Galaxy	Remote controller and Nunchuk controller

and/or using other video games. The control group was given a choice of 1 inactive video game (from among 5; see Table 1) with all necessary peripherals to play that game at the beginning of week 1 and of another at the beginning of week 7. All but one of the video games offered were rated E (Everyone) by the Entertainment Software Rating Board (ie, content suitable for ages 6 and older). DanceDanceRevolution was rated E10+, and parents had to agree that it was acceptable to offer that game to their child. The Wii console was chosen because it was the primary platform for most active video games at the time of the start of the study, and it automatically electronically stored in the console the name and duration of the games played each day. The specific video games and peripherals offered are identified in Table 1. The selection of the video games was based on game sales data of those most purchased for the Wii console at the time of the start of the study. All possible Wii video games were tested by staff and rated as either active or inactive. The 5 selected active games were considered the most active E-rated ones available at the time of the study. The 5 inactive games were the most popular at the time of the study.

Recruitment

Participants were recruited (in 2010) from multiple sources. The professional recruiter of the CNRC identified candidates in the CNRC recruitment database (>9800 names in 2010) who met age criteria and called the parent to preliminarily orally assess inclusionary criteria and interest. The Baylor College of Medicine Public Relations office distributed press releases soliciting participants to local media and via the CNRC "Nutrition and Your Child" quarterly newsletter. Recruitment fliers with tear-away tabs and call numbers were posted around the Texas Medical Center and Rice University campuses, the Harris County Hospital District Pediatric Clinic, and local public libraries and museums.

Prospective parents were sent a cover letter, parental consent form, family demographic form, and information on TV inputs and images to confirm eligibility. The research protocol was approved by the Baylor College of Medicine Institutional Review Board. All participants provided parent-signed consent and child-signed assent. Children were allowed to keep the Wii console, 2 selected video games, and enabling peripherals, if they completed all data collection to acceptable minimum standards (eg, 5 days of accelerometry at each time interval).

Measures

Parents completed the demographics (child gender, child age, child ethnic group, highest educational attainment in the household, parent perception of neighborhood safety) at baseline with commonly used questions from our previous studies.

Neighborhood safety was reported by the parent at baseline by a validated 12-item questionnaire (4 response categories from "strongly disagree" to "strongly agree") that assessed parent-perceived neighborhood safety in regard to traffic, lighting, crime, and access to parks.[16] The Cronbach α in the present sample was 0.82.

Children's height was measured by using the Perspective Enterprise's stadiometer PE-AIM-101 (Portage, MI) with shoes removed according to standard protocol.[17] Two assessments were recorded to the nearest 0.1 cm and averaged. Children's weight was measured using the SECA α 882 digital scale (Hamburg, Germany) with shoes, outer wear, and objects from pockets removed, with feet placed in the center of the scale and eyes looking straight ahead, according to standard protocol.[17] The scale was calibrated by using standard weights any time the scale was moved. Weight was measured once to minimize burden because 2 measures rarely varied. All data collectors were trained to minimum acceptable standards.

PA was assessed with the use of Actigraph GT3×accelerometers (Pensacola, FL). The accelerometer was placed on an elastic belt; the belt was fit to be snug but comfortable for the child; and the accelerometer was placed above the right hip. The child was instructed to wear the accelerometer for 7 consecutive days, and remove it only when going in the water (eg, bathe, swim) or when playing contact sports. A log was provided, and participants were instructed to record when they slept or removed the accelerometer. The monitors were fully charged before they were given to participants. If <7 days were provided, the child was asked to rewear the monitor to complete the number of days. (High compliance was obtained because children wanted to keep the Wii game equipment.) Actigraphs were programmed to start at midnight at the end of the day on which it was provided. The epoch was set to 10 seconds. Values above 17 000 cpm were considered errors and removed, as suggested by the manufacturer. Intervals of 60 continuous minutes or more of recorded zeros were taken as periods of not wearing the monitor. The minimal acceptable period at each data collection time interval was 5 days of 600 minutes per day. The Evenson cut points[18,19] were used to define levels of moderate or vigorous, light and sedentary behaviors.

After week 12, the parent returned the Wii console. Staff then transcribed the full file, including machine-recorded date, name, and duration of each game recorded in the console. Children and parents were asked to keep a diary of game play on the Wii console for each week the child wore an activity monitor. The diary included what game was

played at what time for each day, and who played it.

Interviews

Children were interviewed at the mid- and postassessments by using qualitative methods. The interview was designed to take 15 minutes and assessed reasons the child selected the games s/he did, what the child liked and did not like, and with whom the games were played. The interviewers were trained in open-ended interview procedures. The responses were independently double coded by using thematic analysis procedures.[20] Differences were reconciled by consensus among the investigators.

Power

Power analysis for a repeated-measures analysis of covariance to test whether PA varied by group by time showed that, with the final sample size of 78, 2 groups (intervention, control), 5 repeated measures, a correlation over time of 0.66 and an α of 0.05, there was 80% power to detect a moderate effect size (Cohen's $d = 0.21$). To test all the post hoc contrasts of interest, independent t tests were used with an α of 0.01 per pair. Therefore, there was 80% power to detect large effects (Cohen's $d = 0.79$).

Data Analyses

Linear mixed models were used to investigate differences in PA between groups (intervention, control), time (baseline, week 1, week 6, week 7, and week 12), and group by time. Four separate analyses in which either minutes of sedentary, light, or moderate to vigorous PA per day and counts per minute were treated as the dependent variables were run. To test a differential intervention effect on children's PA by parents' perceived neighborhood safety, parents' socioeconomic status, number of video games available in the home, or child BMI z score, all analyses included a group by time by covariate interaction term and all the imbedded 2-way interaction terms. All the analyses were conducted by using the Proc Mixed procedure[21] in Statistical Analysis Systems (version 9.2, 2009, SAS Institute Inc., Cary, NC). For nonnormally distributed data (ie, moderate to vigorous PA), generalized linear mixed models with gamma distribution and a log link function was performed by using PROC GLIMMIX in SAS. α was set at 0.05.

RESULTS

The study began with 84 participants completing baseline assessment and being randomly assigned to the study. Six participants were dropped from the control group for the reasons shown in Fig 1. Of the 78 remaining in the analyses, 41% reported being African American, 14% white, 13% Hispanic, 4% other, and 28% mixed ethnic heritage. Boys composed 51% of the sample. The average age was 11.3±1.8 years, and average BMI percentile was 81.7%. Sixty-four percent of children reported that the Wii console was kept in the living room, and 19% reported that it was kept in the child's bedroom; 49% had a Play Station 2, but only 15% had a Play Station 3; 10% reported having an Xbox and 17% had an Xbox 360; and 58% reported having a TV and 36% a video game console in their bedroom.

The average minutes of moderate to vigorous and light PA, sedentary behavior, and counts per minute for the treatment and control groups appear in Table 2. There was no evidence of treatment-control group, or treatment-control group by time differences in any of these variables over all, or at any time. There was a significant time-related difference in sedentary behavior in week 6, only. There was no evidence of moderation of these effects by neighborhood safety, child BMI z score, highest educational attainment in the home, family income, number of video games, or number of active video games in the home.

The interviews, diaries, and console records all indicated substantial active video game use. Table 3 provides mean minutes for data consistently recorded each week in the diary and Wii console log, active and inactive, by treatment-control groups. Although it is clear that there was substantial crossover in types of games used, the time spent playing games opposite to that assigned (as shown in Table 3) was small in comparison with the time spent playing the type of game assigned.

Child responses to the interview questions were diverse, but indicated that children in both groups enjoyed the active video games, and this was comparable after weeks 6 and 12. What treatment group children "liked best" usually referred to specific PA in the game they selected, eg, boxing or bowling, but also included "didn't have

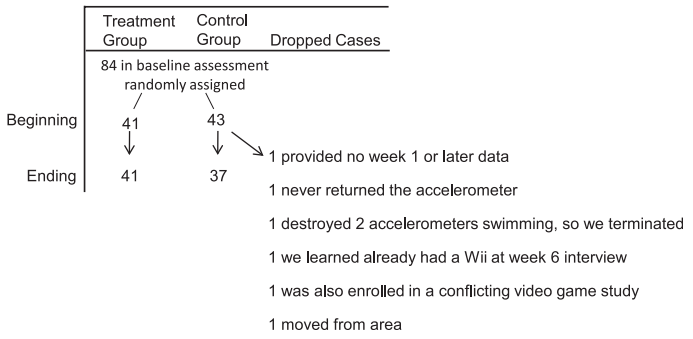

FIGURE 1
Consort statement graphic of flow of participants through the study.

TABLE 2 Average, SD, Median, IQR, Mean Difference, and 95% CI of Minutes per Day (Average for Each Child Across Days) for Treatment and Control Groups for SEDs, LPA, MVPA, and counts per minute

PA Level	Wk	Mean	SD	Median	IQR	Mean	SD	Median	IQR	Mean Diff.	95% CI
SED			Treatment (n = 41)				Control (n = 37)				
	Baseline	662.7	80.71	670.43	94.18	653.91	72.95	635.14	115.25	8.79	(−26.09 to 43.68)
	Wk 1	650.77	76.39	664.88	78	651.06	94.21	644.71	116.91	−0.28	(−39.28 to 38.72)
	Wk 6	762.51	158.03	697.44	244.27	728.05	136.76	720.61	176.03	34.46	(−32.93 to 101.9)
	Wk 7	646.86	78.52	641.38	90.57	652.62	93.7	646.71	122.88	−5.76	(−45.03 to 33.50)
	Wk 12	648.59	87.43	638.57	84.14	636.78	84.45	654.86	113.94	11.81	(−26.98 to 50.60)
LPA			Treatment (n = 41)				Control (n = 37)				
	Baseline	388.4	69.44	375.93	98.45	399.57	63.98	406.57	95.32	−11.18	(−41.47 to 19.12)
	Wk 1	400.37	69.04	392.71	74.2	400.51	80.64	407.71	88.75	−0.14	(−34.21 to 33.93)
	Wk 6	390.7	64.35	392.99	81	401.18	73.04	395.93	86.56	−10.48	(−41.88 to 20.92)
	Wk 7	404.79	68.4	419	83	396.26	81.82	399.5	120.18	8.53	(−25.72 to 42.79)
	Wk 12	400.89	80.86	406.14	85.25	412.52	73.12	399.29	94.29	−11.63	(−46.35 to 23.09)
MVPA			Treatment (n = 41)				Control (n = 37)				
	Baseline	27.42	19.26	22.92	20.7	25.06	13.85	22.14	23.54	2.35	(−5.32 to 10.02)
	Wk 1	27.5	15.16	22.13	16.43	26.91	20.69	23.83	20.43	0.58	(−7.69 to 8.86)
	Wk 6	26.63	18.57	22.93	18.66	25.94	16.93	22.36	30.82	0.68	(−7.49 to 8.85)
	Wk 7	25.29	14	21.71	19.96	29.47	19.48	22.5	30.67	−4.18	(−11.78 to 3.41)
	Wk 12	27.91	14.27	28.67	18.29	27.55	14.98	26.56	19.49	0.36	(−6.31 to 7.03)
CPM			Treatment (n = 41)				Control (n = 37)				
	Baseline	324.13	124.36	295.58	134.34	315.39	92.14	320.41	168.07	8.74	(−40.75 to 58.22)
	Wk 1	324.95	95.21	302.43	124.99	320.69	127.23	310.7	122.62	4.26	(−46.98 to 55.49)
	Wk 6	304.31	117.41	281.57	124.37	303.1	102.29	278.04	139.45	1.2	(−49.36 to 51.76)
	Wk 7	328.15	105.74	320.71	124.55	329.54	118.99	311.9	182.12	−1.4	(−52.43 to 49.63)
	Wk 12	335.93	101.34	333.65	132.32	329.96	94.42	322.11	154.06	5.98	(−38.49 to 50.44)

Cut points for levels of physical activity from Evenson et al[19]: SED ≤100; LPA >100; MPA ≥2296; 4012 ≤VPA ≤ 17 000. CI, confidence interval; CPM, counts per minute; IQR, interquartile range; LPA, minutes of light physical activity; MVPA, minutes of moderate to vigorous physical activity SED, minutes of sedentary behavior.

TABLE 3 Mean, SD of Minutes per Day in Active and Inactive Video Games for Each Group Separately at Each Time Interval

Group	Wk	n	Returned Logs or Did Not Play, n	Active Game		Inactive Game	
				Mean	SD	Mean	SD
Control	Wk 1	37	36	6.47	24.17	27.21	33.89
	Wk 6	37	37	8.16	24.10	21.23	29.48
	Wk 7	37	37	1.93	8.85	59.73	87.51
	Wk 12	37	35	6.17	18.95	17.38	35.54
Treatment	Wk 1	41	41	28.14	31.49	3.75	15.57
	Wk 6	41	40	12.03	13.26	5.53	14.92
	Wk 7	41	40	21.10	24.25	4.18	13.42
	Wk 12	41	40	7.86	10.23	2.57	8.42

The minutes reported are for those games that were consistently reported in both the diary and console log. This may mean that the minutes of game play are underreported.

to go outside" and "doing activities that you wouldn't normally be able to do." When asked what they did not like, some reported difficulties with specific games, eg, "computer competitor would scream things," "I couldn't understand a character," but there was also "didn't have anyone to play with" and "didn't like difficulty level." What control group children liked best included "beating the high score/getting points" and "challenging." Approximately equal percentages of children in the treatment and control groups reported playing each game with someone else (Table 4). Siblings (79% in both groups) were the most commonly reported coplayers, followed by parents (55%, 49%, respectively) and cousins (35%, 38%, respectively).

DISCUSSION

There was no evidence that children receiving 2 active video games and the peripherals necessary to run them were any more active over a 12-week period than those receiving 2 inactive video games. Thus, although children can do moderate or vigorous PA with active video games in laboratory settings,[6,8,22] they either did not elect to play the provided games at that level of intensity, or compensated for the increased intensity by being less active at other times in the day. The attempt in this study was to simulate a family receiving a new active video game and assessing the naturalistic spontaneous activity from that acquisition. These findings are consistent with 1 other naturalistic study[12] and suggest that simply acquiring a new active video game does not automatically lead to increased PA, thereby minimizing the public health value of simply having active video games available for children to play. Providing explicit instructions to use the active video game appears to lead to increased activity,[9,11,23] which may make active video games useful

TABLE 4 Frequency and Percentage of Responses to, "Did anyone else play this game with you in person during the last 6 weeks?" After the First and Second Video Games

	Week 6 (n = 78)			Week 12 (n = 78)		
	Total n (%)	Treatment n (%)	Control n (%)	Total n (%)	Treatment n (%)	Control n (%)
Yes	71 (91)	39 (95)	32 (86)	70 (90)	37 (90)	33 (89)
No	6 (8)	2 (5)	4 (11)	8 (10)	4 (10)	4 (11)
Don't remember	1 (1)	0 (0)	1 (3)	0 (0)	0 (0)	0 (0)
Who was that?						
Parent(s)/guardian(s)	43 (55)	29 (71)	14 (38)	38 (49)	25 (61)	13 (35)
Sibling(s)	62 (79)	33 (80)	29 (78)	62 (79)	33 (80)	29 (78)
Grandparent(s)	7 (9)	4 (10)	3 (8)	3 (4)	2 (5)	1 (3)
Cousin(s)	27 (35)	16 (39)	11 (28)	30 (38)	15 (37)	15 (41)
Other family member(s)	12 (15)	9 (22)	3 (8)	14 (18)	9 (22)	5 (14)
Friend(s)	24 (31)	12 (29)	12 (32)	17 (22)	10 (24)	7 (19)
Other(s)	5 (6)	2 (5)	3 (8)	1 (1)	0 (0)	1 (3)

as part of interventions that prescribe some minimal use. None of the active video games had a narrative or story; wrapping an engaging narrative around the activity in active video games may motivate more intense and maintained PA.[13]

An attempt was made to match the days, games, and play duration recorded on the Wii console file with the days and times of starting game play from the diary, and then identifying the corresponding intervals on the accelerometers to identify specific game play PA. This effort was abandoned, because the console-recorded days were not in synchrony with days in the diary; the durations on the console were at times excessive (eg, up to 24 hours) suggesting that players left the console on with the game in the console, even when not playing; and more than half the names of the games in the diary and the console did not match for the same day and times (when this could be established). The records, however, did reveal that some children receiving the active video games obtained and played inactive games, and vice versa, thereby somewhat "contaminating" the effect, but most of the game play time was consistent with the type of game provided to the child. There was substantial social involvement in game play in both conditions (Table 4), but the Wii console log could not differentiate game play by target child, friend(s), family member(s), or others.

The strengths of the current research were the experimental design with random assignment of participants to groups; restriction of the sample to families without a Wii console to simulate acquisition of a new (to them) active video game; the use of objective monitors of activity over week-long intervals at 5 times in the design; and obtaining complete data on >90% of the sample. The limitations included a modest sample size (the study was not powered to detect equivalence); there was some cross-game contamination, but this was expected in a naturalistic study, and was reasonably low, but we could not assess game play on consoles other than the Wii; we were not able to assess activity during active game play; and the study was conducted only with 9- to 12-year-olds in one city, and thereby may not generalize to children of other ages, in other cities, or using other video games and systems.

CONCLUSIONS

Children (9- to 12-years-old) in a naturalistic setting did not participate in higher levels of PA after receiving a new (to them) video game console and 2 active video games in comparison with those receiving the same console and 2 inactive video games.

REFERENCES

1. Sallis JF. Age-related decline in physical activity: a synthesis of human and animal studies. *Med Sci Sports Exerc*. 2000;32(9):1598–1600
2. Troiano RP, Berrigan D, Dodd KW, Mâsse LC, Tilert T, McDowell M. Physical activity in the United States measured by accelerometer. *Med Sci Sports Exerc*. 2008;40(1):181–188
3. Molnar BE, Gortmaker SL, Bull FC, Buka SL. Unsafe to play? Neighborhood disorder and lack of safety predict reduced physical activity among urban children and adolescents. *Am J Health Promot*. 2004;18(5):378–386
4. Baranowski T, Thompson WO, DuRant RH, Baranowski J, Puhl J. Observations on physical activity in physical locations: age, gender, ethnicity, and month effects. *Res Q Exerc Sport*. 1993;64(2):127–133
5. Whitaker RC, Wright JA, Pepe MS, Seidel KD, Dietz WH. Predicting obesity in young adulthood from childhood and parental obesity. *N Engl J Med*. 1997;337(13):869–873
6. Graves LE, Ridgers ND, Williams K, Stratton G, Atkinson G, Cable NT. The physiological cost and enjoyment of Wii Fit in adolescents, young adults, and older adults. *J Phys Act Health*. 2010;7(3):393–401
7. Howe CA, Freedson PS, Feldman HA, Osganian SK. Energy expenditure and enjoyment of common children's games in a simulated free-play environment. *J Pediatr*. 2010;157(6):936–942.e1–2
8. Bailey BW, McInnis K. Energy cost of exergaming: a comparison of the energy

cost of 6 forms of exergaming. *Arch Pediatr Adolesc Med*. 2011;165(7):597–602

9. Madsen KA, Yen S, Wlasiuk L, Newman TB, Lustig R. Feasibility of a dance videogame to promote weight loss among overweight children and adolescents. *Arch Pediatr Adolesc Med*. 2007;161(1):105–107
10. Mhurchu CN, Maddison R, Jiang Y, Jull A, Prapavessis H, Rodgers A. Couch potatoes to jumping beans: a pilot study of the effect of active video games on physical activity in children. *Int J Behav Nutr Phys Act*. 2008; 5(8)
11. Maddison R, Foley L, Ni Mhurchu C, et al Effects of active video games on body composition: a randomized controlled trial. *Am J Clin Nutr*. 2011;94(1):156–163
12. Maloney AE, Bethea TC, Kelsey KS, et al. A pilot of a video game (DDR) to promote physical activity and decrease sedentary screen time. *Obesity (Silver Spring)*. 2008; 16(9):2074–2080
13. Barnett A, Cerin E, Baranowski T. Active video games for youth: a systematic review. *J Phys Act Health*. 2011;8(5):724–737
14. Fisher RS, Harding G, Erba G, Barkley GL, Wilkins A; Epilepsy Foundation of America Working Group. Photic- and pattern-induced seizures: a review for the Epilepsy Foundation of America Working Group. *Epilepsia*. 2005;46(9):1426–1441
15. Fortier MS, Sweet S, O'Sullivan T, Williams G. A self-determination process model of physical activity adoption in the context of a randomized controlled trial. *Psychol Sport Exerc*. 2007;8:741–757
16. Timperio A, Crawford D, Telford A, Salmon J. Perceptions about the local neighborhood and walking and cycling among children. *Prev Med*. 2004;38(1):39–47
17. Lohman TG, Roche AF, Martorell R. *Anthropometric Standardization Reference Manual*. Champaign, IL: Human Kinetics Books; 1988
18. Trost SG, Loprinzi PD, Moore R, Pfeiffer KA. Comparison of accelerometer cut-points for predicting activity intensity in youth. *Med Sci Sports Exerc*. 2010;43(6):1360–1368
19. Evenson KR, Catellier DJ, Gill K, Ondrak KS, McMurray RG. Calibration of two objective measures of physical activity for children. *J Sports Sci*. 2008;26(14):1557–1565
20. Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol*. 2006;3:77–101
21. Littell, RC, Milliken, GA, Stroup, WW, and Wolfinger, RD. *SAS system for mixed models*. Cary: NC: SAS Institute, Inc; 1996
22. Penko AL, Barkley JE. Motivation and physiologic responses of playing a physically interactive video game relative to a sedentary alternative in children. *Ann Behav Med*. 2010;39(2):162–169
23. Utter J, Scragg R, Schaaf D, Mhurchu CN. Relationships between frequency of family meals, BMI and nutritional aspects of the home food environment among New Zealand adolescents. *Int J Behav Nutr Phys Act*. 2008;5:50

(Continued from first page)

FINANCIAL DISCLOSURE: *The authors have indicated they have no financial relationships relevant to this article to disclose.*

FUNDING: Primarily funded by a grant from the National Cancer Institute (CA66724-01). This work is also a publication of the United States Department of Agriculture/Agriculture Research Service (USDA/ARS), Children's Nutrition Research Center, Department of Pediatrics, Baylor College of Medicine, Houston, Texas, and funded in part with federal funds from the USDA/ARS under Cooperative Agreement No. 58-6250-6001. Funded by the National Institutes of Health (NIH).

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Pediatrics 2012;129;e636; originally published online February 27, 2012;
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