Published in final edited form as:

Am J Prev Med. 2011 January ; 40(1): 33–38. doi:10.1016/j.amepre.2010.09.029.

Video Game Play, Child Diet, and Physical Activity Behavior Change:

A Randomized Clinical Trial

Tom Baranowski, PhD, Janice Baranowski, MPH, RD, Debb Thompson, PhD, Richard Buday, FAIA, Russ Jago, PhD, Melissa Juliano Griffith, MPH, Noemi Islam, MPH, Nga Nguyen, MS, and Kathleen B. Watson, PhD

U.S. Department of Agriculture / Agricultural Resource Service Children's Nutrition Research Center, (T Baranowski, J Baranowski, Thompson, Abdelsamad, Griffith, Islam, Nguyen, Watson), Baylor College of Medicine; Archimage Inc., (Buday), Houston, Texas; Department of Exercise, Nutrition and Health Sciences, (Jago), University of Bristol, United Kingdom

Abstract

Background—Video games designed to promote behavior change are a promising venue to enable children to learn healthier behaviors.

Purpose—Evaluate outcome from playing “Escape from Diab” (Diab) and “Nanoswarm: Invasion from Inner Space” (Nano) video games on children’s diet, physical activity and adiposity.

Design—Two-group RCT; assessments occurred at baseline (B), immediately after Diab (P₁), immediately after Nano (P₂) and 2 months later (P₃). Data were collected in 2008–2009, and analyses conducted in 2009–2010.

Setting/Participants—133 children aged 10–12 years, initially between 50 percentile and 95 percentile BMI.

Intervention—Treatment group played Diab and Nano in sequence. Control Group played diet and physical activity knowledge-based games on popular websites.

Main Outcome measures—Servings of fruit, vegetable and water; minutes of moderate to vigorous physical activity. At each point of assessment: 3 nonconsecutive days of 24-hour dietary recalls, 5 consecutive days of physical activity using accelerometers, and assessment of height, weight, waist circumference and triceps skinfold.

Results—A repeated measures ANCOVA was conducted (analyzed in 2009–2010). Children playing these video games increased fruit and vegetable consumption by about .67 servings per day ($p < 0.018$), but not water, moderate-to-vigorous physical activity, or body composition.

© 2010 American Journal of Preventive Medicine. Published by Elsevier Inc. All rights reserved.

Address correspondence to: Tom Baranowski, PhD, USDA/ARS Children’s Nutrition Research Center, Baylor College of Medicine, Houston, Texas, 77030-2600. tbaranow@bcm.edu.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Richard Buday is the President of Archimage, Inc., the company that created Diab and Nano. No other financial disclosures were reported by the authors of this paper.

Conclusions—Playing Diab and Nano resulted in an increase in fruit and vegetable intake. Research is needed on the optimal design of video game components to maximize change.

Background

Youth obesity rose dramatically during recent decades¹. While the increases since 1999 have been small, there have been no declines from the high levels² with resulting increased prevalence of type 2 diabetes³. Obesity results from energy imbalance, with energy intake exceeding expenditure⁴. Increased fruit and vegetable (FV), and water intakes have been associated with decreased risk of obesity.^{5, 6} Many youth consume less than the recommended minimum of five FV servings⁷ and were physically active for less than the recommended 60 minutes of moderate-to-vigorous physical activity (MVPA) per day.⁸

Serious video games offer promise of innovative channels for effective behavior change⁹. Once a child's attention has been attracted¹⁰ modeling,¹¹ tailoring¹² and feedback¹² can increase personal relevance, while games add fun.¹³ Most health-related video games had some positive outcome,⁹ and video games have effectively promoted dietary change among youth.¹³

“Escape from Diab” and “Nanoswarm: Invasion from Inner Space” (hereinafter called Diab and Nano) were video games designed to lower risks of type 2 diabetes and obesity by changing youth diet and physical activity behaviors. Diab and Nano were designed based on social cognitive¹⁴, self determination,¹⁵ and persuasion¹⁶ theories. The current research tested the hypothesis that children aged 10–12 years playing Diab and Nano would increase FV and water intakes and MVPA, in comparison to a control group.

Methods

Design

This small efficacy trial used a two-arm randomized control design with assessments of play at baseline, between games (post 1), immediate postgame (post 2), and 2-months postgame (post 3). Children were randomly assigned to intervention ($n=103$) or control ($n=50$) groups. Twice as many treatment as control group participants enabled substantial assessment of game play while maintaining the robustness of the F statistic to heterogeneity of differences in variation between groups.¹⁷

Sample

Inclusionary criteria were being aged 10–12 years, between the 50th and 95th percentile for BMI, allowed to play video games, and having high-speed Internet access (to permit transmission of process evaluation data). Exclusionary criteria were the child not speaking English (since both games were in English), having a medical condition that influenced diet, physical activity, obesity, or the ability to complete questionnaires, a seizure disorder, or a member of a swim team.

This project was approved by the Baylor College of Medicine IRB. All parents provided written informed consent and children provided informed assent. Children were recruited primarily with advertisements on a radio station whose listening audience included parents of children in the targeted age groups from ethnic minority communities (African-American, Hispanic).¹⁸

Sample size was set by the funding agency. Power analysis for a repeated measures ANCOVA (RM ANCOVA) to test the outcome, and independent t-tests for pairwise comparisons of the outcomes revealed that 2 groups, 4 repeated measures, a constant

correlation of 0.3, an alpha of 0.05, and a sample size of 153, there was 80% power to detect a small-to-moderate overall effect (Cohen's $d=0.25$).¹⁹ For independent t-tests of post hoc pairwise changes for intervention and control groups, respectively, and an alpha of 0.0125 per pair, there was 80% power to detect moderate change in outcome (Cohen's $d=0.48$).²⁰ Inclusion of covariates in ANCOVAs decreases the power to detect significant effects.

Intervention – Game Design and Format

Quantitative and qualitative methods (i.e., surveys and focus groups) were used to examine child preferences for storyline genres and plot content of nonviolent video games as well as computer access, knowledge and game-play frequency in a sample of predominantly low-income urban middle school students in Texas ($n=196$) and rural middle school students in North Carolina ($n=66$).²¹

Each game had 9 sessions and a minimum of approximately 40 minutes of game-play per session. This totaled approximately 6 hours of new game-play per game. A session-by-session description of each of the components in Diab is in the game overview grid (see Appendix A, available online at www.ajpm-online.net). Each session had a knowledge mini-game designed to provide practical knowledge related to change goals. Energy balance was divided into 18 sequential learning activities such that each ensuing learning session was predicated on mastering that material, which built on material in the previous session. Goal setting included action and coping (anticipatory problem solving) implementation intentions²²; a behavioral inoculation component involving a motivational message with a reasons statement linking the selected behavior change to a personally selected value²³; and a goal behavior menu tailored to usual dietary or physical activity behaviors. A more detailed description of Diab has been presented¹⁶. A similar structure was used for Nano. Children were allowed to take as long as desired in completing all sessions, but completing all sessions was required in the intervention group. Project staff called participants within 3 days of an expected session not played. Duration between measurements was used as a covariate in analysis.

Control Group Intervention

The control group received a knowledge enhancing Internet experience presented in two parts (one for Diab, one for Nano). Each part included a booklet with two discs: one disc connecting to 8 sessions of game-based websites (each related to diet, physical activity and obesity), with questions on the disc to be answered after each session (with immediate feedback); and the second containing a knowledge-based nutrition game (Part 1: “Good Food and Play Make a Balance Day” and Part 2: “Dish It Up”) that was played with the 8 session websites. This control group experience was offered to meet recruits’ expectations of playing health-related video games, and thereby avoid their disappointment and possible higher drop out rate²⁴.

Implementation

Treatment group participants were loaned 24 inch iMac computers with the games and Microsoft Windows XP operating system preinstalled, but had no applications other than the video game interventions. Intervention coordinators monitored child use of the games by organizing and reviewing email messages each time a child completed a session, answering call-in questions, guiding repair of minor hardware or software malfunctions, and arranging for speedy repair of larger malfunctions.

Incentives

Graduated incentives were provided for child participation in data collection: \$25 for baseline assessment; \$30 for between-game assessments; \$35 for immediate postgame assessment; and \$40 for 2-month follow-up.

Measures

For anthropometric assessments and 24-hour dietary recalls, data collectors were blinded to group assignment. Height was measured twice using a PE-AIM-101 stadiometer from Perspective Enterprises (Portage, MI) and averaged. Weight was measured twice using SECA Alpha 882 from the SECA Corporation (Hamburg, GR) and averaged. Waist circumference was measured twice at the iliac crest using a Gulick tape from Fitness Wholesale (Park Twinsburg, OH) and averaged. Triceps skinfold was measured twice on the right side of the body using a Lange Caliper from Cambridge Scientific Industries, Inc (Cambridge, MD) and averaged. If each pair of the anthropometric assessments were not within specified limits (± 1 cm for height, ± 0.2 kg for weight, ± 2 cm for WC, $\pm 10\%$ for skinfold thickness), a third reading was obtained and the two closest averaged. Anthropometric data collection staff were all trained on standardized protocols²⁵ and certified against an accomplished senior staff person.

Physical activity was assessed using Actigraph AM-7164 accelerometers (Manufacturing Technology Inc. Health Services Division, Ft. Walton Beach, Florida) which provide accurate and reliable indices of physical activity among children²⁶. Participants were included in the accelerometer analysis only if they provided at least 4 days of valid accelerometer data. Periods in which 20 or more minutes of zero counts were obtained were interpreted as time when the monitor was not worn. Counts of 32767 indicated a malfunction. Each day of accelerometer data was considered valid if data were obtained for at least 800 minutes. Non-wear and malfunction time periods were removed from analysis. Few children were excluded due to invalid accelerometer data. On average 96% of the children participating in assessment provided 4 or more valid days of accelerometer data across all four time assessments. Among the children providing valid accelerometry, 95% included at least 1 valid weekend day. Little's chi-square (MCAR=130, df=130, p=.473) indicated accelerometer data were missing at random. Mean counts per minute, which provides an indication of the overall volume of physical activity in which a child engaged was calculated for all participants. MVPA was measured as the number of minutes above a specific threshold, averaged across all valid days. The thresholds used in defining sedentary, light, moderate, and vigorous activity levels were based on the thresholds identified by Treuth et al²⁷. The ranges in counts per minute were: sedentary (1–100), light (101–2999), moderate–vigorous (≥ 3000). Mean minutes per activity level was computed as the minutes across valid days. Mean counts per minute was computed as the number of counts per day divided by the number of minutes per day, then averaged.

Three 24-hour dietary recalls were conducted, the first one in person, and the subsequent two over the telephone by RDs who were trained and certified in Nutrient Data System-Research (NDS-R) following accepted procedures²⁸. Regular vegetable (V) intake was defined to exclude high-fat vegetables (e.g., French fries).

The social-desirability-of-response scale (the “lie” scale²⁹) had nine items with a four-category (“never true of me”, “not sure”, “sometimes true of me”, “always true of me”) (0–3) response format and alpha reliability of 0.81 (assessed at baseline only).

Statistical Analysis

Descriptive statistics were calculated as appropriate in 2009–2010. Bivariate correlations (Pearson or Spearman) assessed associations (depending on distributional characteristics) between key variables. A mixed model, accounting for missing repeated measures, examined whether children playing Diab and Nano increased FV, water, or physical activity, compared to the control group. The model contained time (a within-subjects factor: post 1, post 2, post 3) and study group (a between-subjects factor: intervention, control). Separate models were used for each dependent variable (e.g., FV, water intake, physical activity) with baseline used as covariate. A significant main effect was the primary test of outcome. A significant time-by-group interaction indicated a difference in outcome over time between the study groups. For significant interactions, post hoc contrasts indicated a linear or quadratic trend over time for each group. The level of significance was adjusted using the Bonferroni correction, when warranted, for post hoc analyses. In addition to the baseline measure, the model controlled for potential confounding variables (e.g., demographic characteristics, social desirability of response, and duration of game play). The magnitude of the overall effect was explained through the magnitude of the standardized effect size for the F statistic, where 0.10, 0.25, and 0.40 represent small, medium, and large effects, respectively.³⁰ To descriptively present the significant outcomes, smoothed density function graphs were generated for the treatment and control groups at the time of biggest group difference.

RESULTS

The CONSORT statement flow chart (Figure 1) indicates that 260 children were initially contacted with 133 providing complete data. There were no significant differences in any demographic variables between treatment and control groups, or between those retained or eliminated from the sample. The sample had more 10-year-olds, men/boys, whites, and parents with a college degree or higher (Table 1). There were no differences in demographics or anthropometrics between participants with or without missing data. Only 7.5% of all the data were missing across all four time periods. Little's chi-square test of all variables indicated data were missing completely at random [$\chi^2=549.25$, $df=547$, $p=0.465$]. Analyses were performed with and without imputed data and the results were similar.

Despite randomization there were differences in mean levels of FV, nonfat vegetables, total energy, MVPA, counts per minute, BMI percentile and BMI z-score, by group at baseline (Table 1). The diet outcome analyses revealed significant treatment versus control effects at all post assessments on FV intake (small effect size=0.18, $p=0.018$) and its component F intake (moderate effect size=0.26, $p=0.001$) with the largest between-group FV difference ($M=0.67$, 95% CI=0.25, 1.09) at post test 3 assessment (marginal group $\times$ visit $p=0.083$) (Table 2). The density function graph (Figure 2) showed mean FV differences with the treatment group having higher intake in the right tail, while the control group had higher intake in the center of the distribution. There were no significant effects for the other variables. Post game questionnaires with children and interviews with parents revealed that most children (80%–90%) enjoyed playing both Diab and Nano.

DISCUSSION

Diab and Nano combined had a meaningful effect on dietary FV intake which is comparable to others reported in the literature.^{31, 32} The average BMI percentile across both groups at baseline was 78 percentile. Since most interventions showing effects did so primarily among samples with a minimum participation requirement above the 85 percentile,³³ repeating this intervention with a higher-risk group may result in more positive outcomes.

Although these findings advance research on effects of video games on changing children's FV intake and physical activity, several limitations should be noted. Most measures including FV intake, involved self-reported data which are subject to memory error and reliability concerns. However, physical activity was measured with accelerometry³⁴. Despite random assignment to conditions, initial differences in key measures may have impaired the ability to detect changes. The sample size (set by the funding agency) was underpowered to detect some of the outcome effects. While the games were designed and were reported to be enjoyable, it is not clear what percentage of children would have played to completion without the measurement incentives. It is possible that making advancement in the games conditional on behavior change (e.g., actual physical activity or FV intake) would have enhanced efficacy. The possible mediation of knowledge needs to be addressed in future research. There was an increase in sedentary behavior in the treatment group; while not significant, this requires future attention.

CONCLUSION

Diab and Nano were designed as epic video game adventures, comparable to commercial quality video games. These games incorporated a broad diversity of behavior change procedures woven in and around engrossing stories. The games motivated players to substantially improve diet behaviors. FV and water consumption and physical activity were still below the minimum recommendations indicating that more work is needed. Serious video games hold promise, but their effectiveness and mechanisms of change among youth need to be more thoroughly investigated.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

This research was primarily funded by a grant from the National Institute of Diabetes and Digestive and Kidney Diseases (5 U44 DK66724-01). This work is also a publication of the U.S. Department of Agriculture (USDA/ARS) Children's Nutrition Research Center, Department of Pediatrics, Baylor College of Medicine, Houston, Texas, and had been funded in part with federal funds from the USDA/ARS under Cooperative Agreement No. 58-6250-6001. 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 U.S. government.

REFERENCES

1. Ogden C, Carroll M, Curtin L, McDowell M, Tabak C, Flegal K. Prevalence of overweight in the U.S., 1999–2004. *Journal of American Medical Association* 2006;295(13):1549–1555.
2. Ogden CL, Carroll MD, Curtin LR, Lamb MM, Flegal KM. Prevalence of high body mass index in U.S. children and adolescents, 2007–2008. *JAMA* 303(3):242–249. [PubMed: 20071470]
3. Stommel M, Schoenborn CA. Variations in BMI and Prevalence of Health Risks in Diverse Racial and Ethnic Populations. *Obesity* (Silver Spring).
4. Krebs NF, Himes JH, Jacobson D, Nicklas TA, Guilday P, Styne D. Assessment of child and adolescent overweight and obesity. *Pediatrics* 2007;120 Suppl 4:S193–S228. [PubMed: 18055652]
5. Dennis EA, Flack KD, Davy BM. Beverage consumption and adult weight management: A review. *Eating Behaviors* 2009;10(4):237–246. [PubMed: 19778754]
6. Rolls BJ, Drewnowski A, Ledikwe JH. Changing the energy density of the diet as a strategy for weight management. *Journal of American Dietetic Association* 2005;105(5 Suppl 1):S98–S103.
7. Baranowski T, Smith M, Hearn M, Lin L, Baranowski J, Doyle C, Resnicow K, Wang DT. Patterns in children's fruit and vegetable consumption by meal and day of the week. *Journal of the American College of Nutrition* 1997;16:216–223. [PubMed: 9176827]

8. Troiano RP, Berrigan D, Dodd KW, Masse LC, Tilert T, McDowell M. Physical activity in the U.S. measured by accelerometer. *Med & Sci Sports Exerc* 2008;40(1):181–188. [PubMed: 18091006]
9. Baranowski T, Buday R, Thompson DI, Baranowski J. Playing for real: video games and stories for health-related behavior change. *American Journal of Preventive Medicine* 2008;34(1):74–82. [PubMed: 18083454]
10. Petty, RE.; Cacioppo, JT. Communication and persuasion: Central and peripheral routes to attitude change. New York, Inc: Springer-Verlag; 1986. p. 34
11. Bandura, A. Social Foundations of Thought and Action: A Social Cognitive Theory. Englewood Cliffs, NJ: Prentice Hall; 1986.
12. Kreuter, M.; Farrell, D.; Olevitch, L.; Brennan, L. Tailoring Health Messages: Customizing Communication With Computer Technology. Mahwah, NJ: Lawrence Erlbaum Associates, Publishers; 2000.
13. Baranowski T, Baranowski J, Cullen KW, Marsh T, Islam N, Zakeri I, Honess-Morreale L, DeMoor C. Squire's quest! Dietary outcome evaluation of a multimedia game. *American Journal of Preventive Medicine* 2003;24(1):52–61. [PubMed: 12554024]
14. Bandura, A. Social Foundations of Thought and Action: A Social Cognitive Theory. Englewood Cliffs, NJ: Prentice Hall; 1986.
15. Ryan RM, Deci EL. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychology* 2000;55:68–78.
16. Thompson D, Baranowski T, Buday R, Baranowski J, Thompson V, Jago R, Griffin M. Serious Video Games for Health: How Behavioral Science Guided the Development of a Serious Video Game. *Simulation & Gaming*. 2010 (in press).
17. Stevens, J. Applied multivariate statistics for the social sciences. New Jersey: Lawrence Erlbaum Associates, Inc; 1996.
18. Thompson D, Canada A, Bhatt R, Davis J, Plesko L, Baranowski T, Cullen K, Zakeri I. eHealth recruitment challenges. *Evaluate Program Planning* 2006;29(4):433–440.
19. Hintze, J. PASS 2008, NCSS, LLC. Kaysville, Utah: 2008.
20. Faul F, Erdfelder E, Lang AG, Buchner A. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav Res Methods* 2007;39(2):175–191. [PubMed: 17695343]
21. Thompson, V.; Thompson, D.; Baranowski, T. Internet Access and the Digital Divide. Nova Publishers; 2010. Understanding "serious video game" storyline and genre preferences related to game immersion among low-income ethnically diverse urban and rural adolescents. (in press)
22. Thompson D, Baranowski T, Cullen K, Watson K, Liu Y, Canada A, Bhatt R, Zakeri I. Food, fun, and fitness Internet program for girls: pilot evaluation of an e-Health youth obesity prevention program examining predictors of obesity. *Preventive Medicine* 2008;47(5):494–497. [PubMed: 18718846]
23. Thompson D, Baranowski T, Buday R. Conceptual Model for the Design of a Serious Video Game Promoting Self-Management among Youth with Type 1 Diabetes. *J Diabetes Sci Technol* 4(3): 744–749. [PubMed: 20513343]
24. Lindstrom D, Sundberg-Petersson I, Adami J, Tonnesen H. Disappointment and drop-out rate after being allocated to control group in a smoking cessation trial. *Contemp Clin Trials* 31(1):22–26. [PubMed: 19758579]
25. Lohman TG, Caballero B, Himes JH, Davis CE, Stewart D, Houtkooper L, Going SB, Hunsberger S, Weber JL, Reid R, Stephenson L. Estimation of body fat from anthropometry and bioelectrical impedance in Native American children. *Int J Obes Relat Metab Disord* 2000;24(8):982–988. [PubMed: 10951536]
26. Freedson PS, Melanson E, Sirad J. Calibration of the Computer Science and Application, Inc. Accelerometer. *Medicine and Science in Sports and Exercise* 1998;30:1–5.
27. Treuth MS, Schmitz K, Catellier DJ, McMurray RG, Murray DM, Almeida MJ, Going S, Norman JE, Pate R. Defining accelerometer thresholds for activity intensities in adolescent girls. *Med Sci Sports Exerc* 2004;36:1259–1266. [PubMed: 15235335]
28. Cullen KW, Watson K, Himes JH, Baranowski T, Rochon J, Wacławski MA, Sun W, Stevens M, Slawson DL, Matheson D, Robinson TN. Evaluation of quality control procedures for 24-hour

- dietary recalls: Results for the Girls health Enrichment Multi-site Studies (GEMS). *Preventive Medicine* 2004;38:S14–S23. [PubMed: 15072855]
29. Reynolds CR, Paget KO. National normative and reliability data for the Revised Children's Manifest Anxiety Scale. *School Psych Rev* 1983;12:324–336.
30. Cohen, J. *Statistical power analysis for the behavioral sciences*. Hillsdale, NJ: Lawrence Earlbaum; 1988.
31. Baranowski T, Baranowski J, Cullen KW, deMoor C, Rittenberry L, Hebert D, Jones L. 5 a day Achievement Badge for African-American Boy Scouts: pilot outcome results. *Prev Med* 2002;34(3):353–363. [PubMed: 11902852]
32. Baranowski T, Davis Hearn M, Resnicow K, Baranowski J, Doyle C, Smith M, Lin L, Wang DT. Gimme 5 fruit, juice and vegetables for fun and health: Outcome evaluation. *Health Education and Behavior* 2000;27:96–111. [PubMed: 10709795]
33. Ledoux T, Hingle M, Baranowski T. Relationship of fruit and vegetable intake with adiposity: A systematic review. *Obes Reviews*. 2010 (in press).
34. Riddoch CJ, Leary SD, Ness AR, Blair SN, Deere K, Mattocks C, Griffiths A, Davey Smith G, Tilling K. Prospective associations between objective measures of physical activity and fat mass in 12–14 year old children: the Avon Longitudinal Study of Parents and Children (ALSPAC). *Br Med J* 2009;339(b4544)

Figure 1.
A CONSORT statement figure of loss of participants by point after initial recruitment

Figure 2.

Density function graph of group difference in fruit and vegetable intake at Post-test 3

^a The probability density function is between 0–1, where 0=0% probability and 1=100% probability

Table 1Participant characteristics^a by treatment and control groups.

	Treatment	Control	Total
Characteristics	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)
Total <i>n</i> (% within row)	103 (65.4)	50 (34.6)	153 (100.0)
Age <i>n</i> (%) years			
10	43 (41.7)	22 (44.0)	65 (42.5)
11	34 (33.0)	16 (32.0)	50 (32.7)
12	26 (25.2)	12 (24.0)	38 (24.8)
Gender <i>n</i> (%)			
Female	45 (43.7)	22 (44.0)	67 (43.8)
Male	58 (56.3)	28 (56.0)	86 (56.2)
Race/Ethnic <i>n</i> (%)			
White	37 (35.9)	24 (48.0)	61 (39.9)
African-American	28 (27.2)	9 (18.0)	37 (24.2)
Hispanic	28 (27.2)	15 (30.0)	43 (28.1)
Other	10 (9.7)	2 (4.0)	12 (7.8)
Highest household education <i>n</i> (%)			
Some college or less	31 (30.1)	17 (34.0)	48 (31.4)
College degree or more	72 (69.9)	33 (66.0)	105 (68.6)
Diet <i>M</i> (<i>SE</i>)			
FV ^b	1.65 (0.11)	2.21 (0.18)	1.83 (0.10)
F	0.53 (0.06)	0.65 (0.12)	0.57 (0.05)
RVEG ^c	0.70 (0.05)	0.92 (0.09)	0.78 (0.05)
Water	11.35 (1.14)	12.16 (1.57)	11.61 (0.92)
Total energy ^d	1,617 (43)	1,770 (64)	1,667 (36)
Physical activity (PA) <i>M</i> (<i>SE</i>)			
Sedentary	626 (8)	605 (9)	620 (6)
Light	436 (8)	452 (9)	441 (6)
Moderate-to-Vigorous ^e	18 (1)	23 (2)	20 (1)
Counts per minute ^f	364 (12)	405 (18)	378 (10)
Missing baseline PA <i>n</i> (% within row)	2 (1.9)	5 (7.5)	7 (4.6)
Body Composition <i>M</i> (<i>SE</i>)			
BMI percentile ^g	79.61 (1.26)	74.24 (1.99)	77.86 (1.09)
BMI z-score ^h	0.92 (0.05)	0.73 (0.07)	0.86 (0.04)
Triceps	16.61 (0.45)	16.41 (0.71)	16.54 (0.38)
Waist Circumference	72.01 (0.75)	70.48 (1.00)	71.51 (0.60)

^aPercentage within columns unless otherwise specified; no differences in demographic characteristics between participants with and without missing data; Little's chi-square test indicated that the data were missing completely at random [$X^2_{547}=549.25$, $p=.465$].

Baseline group differences:

$b_{F1,151}=7.79, p=.006, R^2_{veg} (1,151)$

$c_{F1,151}=4.93, p=.028,$

$d_{F1,151}=4.00, p=.048,$

$e_{F1,147}=3.81, p=.053,$

$f_{F1,147}=4.23, p=.041,$

$g_{F1,147}=5.55, p=.020,$

$h_{F1,147}=5.26, p=.023.$

Table 2

Adjusted means, SEs, and tests of group and group $\times$ visit interaction terms from mixed-model repeated measures ANCOVA^a

Dependent Variables	Statistics, effect size						Treatment			Control		
	Group		Group $\times$ Visit		Post 1		Post 2		Post 3		Post 1	
	F	p	F	p	F	p	F	p	F	p	F	p
Diet (Servings)					(n=98)		(n=92)		(n=93)		(n=49)	
FV ^c	5.73	0.018	0.18	2.51	0.083	0.14	1.88 (0.13)	1.85 (0.13)	2.15 (0.13)	1.56 (0.18)	1.72 (0.19)	1.48 (0.19)
F	10.93	0.001	0.26	3.57	0.029	0.19	0.58 (0.06)	0.49 (0.07)	0.63 (0.07)	0.42 (0.09)	0.34 (0.10)	0.19 (0.10)
RV ^c	0.44	0.508	0.00	2.45	0.089	0.14	0.75 (0.07)	0.79 (0.07)	0.85 (0.07)	0.76 (0.10)	1.02 (0.10)	0.77 (0.11)
Water (oz) ^c	2.51	0.116	0.10	0.35	0.704	0.00	12.81 (1.09)	12.82 (1.12)	12.32 (1.12)	11.69 (1.52)	10.07 (1.62)	9.99 (1.65)
Tot Energy (kcal) ^c	1.69	0.196	0.07	1.00	0.370	0.00	1604 (41)	1568 (42)	1632 (42)	1657 (58)	1693 (62)	1653 (63)
Physical Activity (min)					(n=94)		(n=90)		(n=88)		(n=46)	
Sedentary	1.92	0.169	0.08	0.01	0.988	0.00	640 (7)	653 (7)	656 (8)	629 (10)	639 (11)	644 (11)
Light	2.71	0.102	0.11	0.17	0.848	0.00	421 (7)	408 (7)	405 (7)	432 (10)	426 (10)	418 (10)
Mod-Vigorous PA ^c	0.47	0.496	0.00	1.49	0.228	0.08	19 (2)	20 (2)	19 (2)	20 (2)	15 (2)	19 (2)
Counts per Minute	0.08	0.785	0.00	0.92	0.399	0.00	354 (12)	353 (12)	349 (12)	361 (17)	333 (18)	349 (18)
Body Composition					(n=98)		(n=92)		(n=93)		(n=49)	
BMI % ^c	2.63	0.107	0.11	0.68	0.509	0.00	77.41 (0.74)	77.42 (0.75)	77.28 (0.75)	75.12 (1.04)	76.04 (1.08)	75.98 (1.09)
BMI z (z) ^c	2.03	0.156	0.08	0.81	0.448	0.00	0.85 (0.02)	0.84 (0.02)	0.83 (0.02)	0.78 (0.03)	0.81 (0.03)	0.80 (0.03)
Triceps (mm)	0.05	0.825	0.00	0.28	0.758	0.00	15.94 (0.28)	15.34 (0.29)	15.20 (0.29)	15.73 (0.39)	15.42 (0.41)	15.09 (0.41)
WC (cm)	0.48	0.489	0.00	0.39	0.680	0.00	71.14 (0.43)	71.83 (0.44)	72.38 (0.44)	71.01 (0.60)	71.58 (0.63)	71.63 (0.64)

Abbreviations: Value for F statistic (F), probability (p), effect size for F statistic (f); fruit, 100% juice, regular vegetables (lowfat) (FV), physical activity (PA), BMI Percentile, BMI% · BMI z scores (BMI z), waist circumference (WC)

^aMixed model included the school random effect and controlled for age group, gender, race, household education, social desirability, and baseline assessment of the variable of interest.

^bEffect sizes (Cohen's f): f = sqrt ((df/N)*(F-1)); Small effect (.10), Medium effect (.25), Large effect (.40)

^cIndicates variables for which there were baseline differences.