Published in final edited form as:
Int J Obes (Lond). 2013 October ; 37(10): 1314–1321. doi:10.1038/ijo.2013.76.

The Effect of the Home Environment on Physical Activity and Dietary Intake in Preschool Children

Truls Østbye, MD, PhD[1,2], **Rahul Malhotra, MD**[2], **Marissa Stroo, BS**[1], **Cheryl Lovelady, PhD**[3], **Rebecca Brouwer, MS**[4], **Nancy Zucker, PhD**[5], and **Bernard Fuemmeler, PhD, MPH**[1]

[1]Department of Community and Family Medicine, Duke University Medical Center, Durham, NC

[2]Program in Health Services and Systems Research, Duke-National University of Singapore Graduate Medical School, Singapore

[3]Department of Nutrition, The University of North Carolina at Greensboro, Greensboro, NC

[4]Duke Global Health Institute, Duke University, Durham, NC

[5]Department of Psychiatry and Behavioral Sciences, Duke University Medical Center, Durham, NC

Abstract

Background—The effects of the home environment on child health behaviors related to obesity are unclear.

Purpose—To examine the role of the home physical activity (PA) and food environment on corresponding outcomes in young children, and assess maternal education/work status as a moderator.

Methods—Overweight or obese mothers reported on the home PA and food environment (accessibility, role modeling and parental policies). Outcomes included child moderate-vigorous PA (MVPA) and sedentary time derived from accelerometer data and two dietary factors ("junk" and healthy food intake scores) based on factor analysis of mother-reported food intake. Linear regression models assessed the net effect (controlling for child demographics, study arm, supplemental timepoint, maternal education/work status, child body mass index and accelerometer wear-time (for PA outcomes)) of the home environment on the outcomes and moderation by maternal education/work status. Data was collected in North Carolina from 2007–2011.

Results—Parental policies supporting PA increased MVPA time, and limiting access to unhealthy foods increased the healthy food intake score. Role modeling of healthy eating behaviors increased the healthy food intake score among children of mothers with no college education. Among children of mothers with no college education and not working, limiting access to unhealthy foods and role modeling reduced "junk" food intake scores while parental policies supporting family meals increased "junk" food intake scores.

Conclusions—To promote MVPA, parental policies supporting child PA are warranted. Limited access to unhealthy foods and role modeling of healthy eating may improve the quality of the child's food intake.

Address correspondence to: Professor Truls Østbye, Department of Community and Family Medicine, DUMC Box 104006, Durham, NC 27710, Truls.Ostbye@duke.edu, Phone: 919-681-3178.

CONFLICT OF INTEREST

The authors have no conflicts of interest to disclose.

Keywords

Childhood obesity; home environment; parenting; physical activity; dietary intake

BACKGROUND

In the United States 26.7% of children aged 2–5 years are overweight or obese (body mass index (BMI) ≥ 85^{th} percentile).(1) While childhood obesity has a complex etiology, the home environment influences children's weight by shaping their dietary and physical activity behaviors.(2, 3)

Aspects of a child's home environment can promote physical activity. Parents encourage physical activity in the home through example, via the availability of and accessibility to play spaces and equipment, and by the norms or rules they establish for physical activity, such as the amount of time they encourage children to play outside.(4) Children with two active parents exhibit higher levels of activity than those with one or no active parents.(5) This may be due in part to genetic predispositions that may encourage movement, but also through positive norms around an active lifestyle, and increased opportunities for exercise created by such parents.(5, 6)

A child's home environment can also promote healthy dietary patterns. For example, availability and accessibility of fruits and vegetables in the home are positively correlated with the level of consumption.(7–9) Conversely, access to unhealthy foods, such as sweetened beverages and unhealthy snacks, is correlated with increased energy intake in children.(10, 11) Parental "policies" are also critical for healthy dietary patterns and include regularity of meal times and the number of weekly meals eaten together as a family.(12, 13) Finally, parents' role modeling of food preferences and eating behaviors also matter. In fact, a parent's positive role modeling may be as important for the prevention of childhood obesity than their feeding practices (i.e., food restriction and control).(14) At an early age, children observe their parents' eating behaviors and typically eat what their parents, especially their mothers, eat.(15) Early experiences may have a lasting impact on food preferences and eating behaviors.(16)

All these aspects of the home environment (access, availability, parental role modeling and parental policies) interact with other, broader, aspects of the family situation. The home environment is a complex social system and what "works" to promote healthy lifestyle choices in some families may not work for others. One key individual differentiator in shaping the relevance of home environment variables may be socioeconomic status (SES). SES is often defined as household income; but other aspects of SES, such as maternal work status and education, likely also affect the home environment.(17–19) For instance, work status may affect the amount of time a mother is able to interact with her child, which in turn may limit the effect of role modeling.(20) The mother's education has a beneficial effect on child dietary intake(21, 22) and has also been shown to shape her perception of weight status: a mother with less education is less likely to correctly identify her child as overweight.(23) Understanding how individual factors, such as SES, can moderate the influence of multiple facets of the home environment on child dietary and physical activity behaviors is critical to designing prevention strategies.

Although associations between home environment and childhood obesity have been reported, only a few studies (10, 11, 24) have explored the concurrent effects of multiple home environment factors on diet and activity level outcomes. Further, we were unable to find any studies that explored the role of maternal education and work status as a moderator of this association. The current study examines the effects of multiple home physical activity and food environment factors (role modeling, policies, and accessibility), assessed using a comprehensive measure, on corresponding outcomes in children from a community-based sample. The study also assesses the potential differences in these associations by maternal education and work status.

METHODS

Study population and recruitment

The data for the current analyses are from the KAN-DO (Kids and Adults Now – Defeat Obesity!) study and its supplemental study about the role of the family in the development of healthy habits. The rationale and design of the KAN-DO study, a randomized control trial targeting postpartum women and their children aged 2–5, approved by the Institutional Review Boards of the Duke University Health System and University of North Carolina - Greensboro and registered with Clinicaltrials.gov (NCT00563264), have been presented in detail previously.(25) At one of the two post-intervention follow-up visits (approximately 12 months [“follow-up 1”] and 24 months [“follow-up 2”] post-baseline) participants in either the KAN-DO intervention or control group were approached about participating in a supplemental study. To be eligible for the supplemental study, women must have had someone living in their home who shared parenting responsibilities (i.e., a “partner”). Mothers taking part in the supplemental study completed a questionnaire that included the Home Environment Survey(27) (HES), developed to evaluate how the home environment can support physical activity and healthy eating in children. Preschoolers (n=208) of the mothers participating in the supplemental study constituted the primary sample for the current analysis (see Figure 1 for study flow diagram).

Outcome variables

Dietary Factors—Mothers reported on their preschooler’s intake over the past week of obesity-related food items using a food frequency questionnaire (FFQ) widely used in North Carolina public health programs.(28) Using previously described methods(29) we derived two dietary factor scores from the FFQ items. One factor (“junk” food intake score) consisted of servings of soda and sweetened drinks,(30, 31) desserts, french fries and chips, and the number of times fast food was consumed per week.(32, 33) A higher score indicates consumption of more “junk” food. Examination of the amount of constituent food items in each quartile of the “junk” food intake score showed a stepped pattern of consumption with increasing quartile for each food item. The amount of soda and sweetened drinks consumed daily seemed to be most influential, increasing from 0.5 ounces in the 1st quartile to 15 ounces in the 4th quartile. The corresponding increase in the number of times fast food was consumed was 0.5 times in the 1st quartile to 2 times in the 4th quartile, and in the number of servings of french fries and chips from 0.1 servings in the 1st quartile to 0.8 servings in the 4th quartile. The second factor (healthy food intake score) consisted of servings of milk, yogurt, and fruits and vegetables.(34, 35) A higher score indicates more consumption of these healthy foods. Similar to the “junk” food intake score, the amount of constituent food items consumed in each quartile of the healthy food intake score showed increased with increasing quartile. For example, the number of daily servings of vegetables increased from 0.9 servings in the 1st quartile to 2.6 servings in the 4th quartile, and of fruits increased from 0.9 servings in the 1st quartile to 2.3 servings in the 4th quartile.

Physical Activity—Preschooler physical activity was measured using Actical accelerometers(36–38) (model #198-0200, Mini-Mitter Co. Inc., Bend, Oregon). Collection of accelerometer data for the preschoolers was part of the main study at the baseline and follow-up 1 visits; for the purposes of these analyses the follow-up 1 accelerometer data was used for everyone. The Actical provides valid and reliable estimates of physical activity in preschool children.(39) Children were asked to wear monitors above the right hip for seven days during waking hours, except while bathing or swimming. Spurious counts, such as consecutive nonzero minutes lasting more than 20 minutes, were flagged, assessed, and set to missing if deemed to be invalid. A valid day for inclusion was defined as at least six hours of wear time. To be included in the analysis, each participant needed to contribute at least three valid days of accelerometer data, including one weekend day and two weekdays. Data were summarized as minutes of moderate to vigorous physical activity (MVPA) and sedentary behavior. MVPA time was defined as ≥ 715 counts/15 second epoch,(39) and sedentary time as <12 counts/15 second epoch,(40) with more than 20 consecutive minutes of zeroes constituting non-wear time.

Predictor variables

Home physical activity environment—Three physical activity-related subscales of the original HES were included in the analyses: “Accessibility of physical activity equipment and play spaces” (4 items), “Role modeling of physical activity” (6 items) and “Parental policies in support of physical activity” (5 items). These three subscales are derived from mean scores of the included items (each item scored on a five point Likert-type scale, ‘Never’ [=0], ‘Rarely’, ‘Sometimes’, ‘Frequently’ and ‘Always’ [=4]). Since the creation of the original HES did not involve the use of factor analysis(27), to assess their applicability in our data, we subjected the 15 items of three subscales to an exploratory factor analysis (EFA), using the principal axis/factors method to extract factors, followed by an oblique rotation. The presence of three underlying factors was supported by a combination of the eigenvalues (≥1), proportion of variance explained (≥10%) and the scree test. Then, factor loadings were examined for sufficiency (>0.40 on at least one factor) and uniqueness (loading on other factors at least 0.20 lower than the highest loading). Three items (one from each subscale: number of toys in good condition, how often your child heard you say you were too tired to be active, how often you sent your child outside to play) did not have sufficient factor loadings for any of the three factors in our data and were deleted. Details of the three modified subscales, which retain the names of the original subscales, are as follows: “Accessibility of physical activity equipment and play spaces” (3 items, α=0.65), “Role modeling of physical activity” (5 items, α=0.80) and “Parental policies in support of physical activity” (4 items, α=0.75).

Home food environment—A similar analytical approach was used to assess the applicability of the items from the three HES food environment subscales (range 0–4) corresponding to those considered for the physical activity environment: Fat/sweet food accessibility (4 items), Role modeling of healthy eating (12 items) and Parental policies for healthy eating (10 items). While the EFA supported the presence of three factors, eleven of the items did not have sufficient and/or unique factor loadings for any of the three factors. We therefore reran the factor analysis after excluding these items, and then regrouped the 15 remaining items into three new factors (or subscales) based on their factor loadings. The score for each of the three subscales reflected the mean score of the included items (each item scored on a five point Likert-type scale). In the first subscale, “Limited access to unhealthy foods” (4 items, α=0.62), a higher score indicated that unhealthy foods (soda and unhealthy snacks) were less accessible to the child. “Role modeling of healthy eating behaviors” (4 items, α=0.79), included items such as “How often did you eat meals or snacks when you were bored when your child could see”: a higher score reflected more limited exposure for the children to unhealthy eating behaviors. The final subscale, “Parental policies in support of family meals” (7 items, α=0.74) included items such as “How often do you prepare meals with your child” and “How often did you have regularly scheduled meals and snacks with your family”, a higher score reflecting stronger parental policies.

Moderator variable and covariates

Given the interrelationship between maternal education and work status, mothers were grouped into four mutually exclusive groups: No college/not working, No college/working, College/not working, and College/working. Since maternal income and education were highly correlated (polychoric correlation=0.77, p<.0001), income was not included in these analyses.

Child age, sex, race (black versus others), study arm, timing of the supplemental assessment (collected at follow-up 1 or follow-up 2), weight status (based on CDC BMI percentile)(41) and accelerometer wear time (for physical activity outcomes) were considered as covariates.

Analysis

Using bivariate linear regression models, we compared mean values of the physical activity and dietary intake outcomes across categories of the covariates and the moderator variable. Pearson's correlation coefficients were calculated to assess the correlation of the home physical activity and food environment subscales with the corresponding outcomes. Only participants with complete information on the predictor and outcome variables were included in the analyses of physical activity (n=149) and dietary intake (n=190) outcomes (145 included with both outcomes, 4 with physical activity only, 45 with dietary intake only, and 14 excluded due to missing data, see Figure 1).

Four separate multivariable linear regression models, one for each of the four outcomes were performed to examine the association between the home physical activity environment subscales and the two physical activity outcomes, and the home food environment subscales and the two dietary intake outcomes. The multivariable models also included the covariates listed above. To assess whether the relationship between the home physical activity and food environment subscales and corresponding outcomes varied by maternal education/work status, interaction terms between the relevant home environment subscales and the maternal education/work status variable (reference category: No college/not working) were introduced in the models for each of the four outcomes. Only significant interaction terms were retained. P-values less than 0.05 were considered statistically significant. To more directly compare the effect of the different risk factors with each other, standardized betas were also calculated. All analyses were done using SAS version 9.2.(42)

RESULTS

The children constituting the primary sample for the current analysis (n=208) were predominantly male (56%), under age 5 (55%), White (85%), and of healthy weight (BMI <85th percentile; 75%). The mothers were relatively well-educated, although 25% had a high school degree or less, and 42% were not currently working for pay. The primary sample for the current analysis did not significantly differ from the overall KAN-DO study sample on any of the key demographic factors (data not shown). Of the 208 participants 96 were approached and completed the supplemental questionnaire at the follow-up 1 visit, and 112 different individuals completed the questionnaire at the follow-up 2 visit. Dietary data from the visit where participants completed the supplemental questionnaire was used. Accelerometer data from the immediate follow-up 1 visit was used for all supplement participants in these analyses since accelerometer data were not collected at the subsequent visit (mean of 238 days between collection of HES and accelerometer data, range from 0–538 days).

Among the 149 children in the primary sample who had information on the physical activity outcomes obtained at the time of their follow-up 1 visit, the mean MVPA and sedentary time per day was 17 minutes (SE=0.90) and 383 minutes (SE=5.83), respectively. In bivariate analyses of the physical activity outcomes, older children (≥5 years old) had significantly less sedentary time (371 vs. 396 minutes, p=0.03) and more MVPA time (15 vs. 20 minutes, p=0.02) than their younger counterparts. Among the 190 children in the primary sample with information on the dietary intake outcomes, Black children, relative to children of White/ other races consumed more "junk" food (factor score of 0.49 vs. −0.08, p=0.01; Table 1).

Physical Activity Outcomes

The "Parental policies in support of physical activity" subscale was positively correlated with MVPA time (Table 2). In the multivariable linear regression models (Table 3a), "Parental policies in support of physical activity" and child age were significantly associated with MVPA time. None of the three home physical environment subscales was significantly associated with sedentary time, though the inverse association of "Role modeling of physical activity" had a p-value of 0.07. Relative to children of mothers with no college education and not working, those of mothers in the three other education/work status groups had significantly higher sedentary time. However, none of the interaction terms between the home physical activity environment subscales and maternal education/work status were significant for either of the physical activity outcomes (data not shown).

Dietary Outcomes

The "Limited access to unhealthy food" and "Parental policies in support of family meals" subscales were positively correlated with the healthy food intake score. All three home food environment subscales were negatively correlated with the "junk" food intake score (Table 2).

In the multivariable analysis (Table 3b), "Limited access to unhealthy food" was associated with the healthy food intake score, irrespective of maternal education/work status. However, the association between "Role modeling of healthy eating behaviors" and healthy food intake scores was modified by maternal education status. In homes with less educated mothers, children consumed more healthy food when mothers' role modeled healthy eating. In homes with more educated mothers, children ate *less* healthfully when mothers' role modeled healthy eating. Maternal education/work status moderated the association of all three food environment subscales with "junk" food intake. The inverse association of "Limited access to unhealthy food" and of "Role modeling of healthy eating behaviors" with "junk" food intake scores was strongest among children of mothers with no college education and not working. While there was a positive association of "Parental policies in support of family meals" with "junk" food intake scores among children of mothers with no college education and not working, an inverse association was observed among children of mothers with the other three maternal education/work status combinations (Table 3b; Figure 2).

DISCUSSION

The present study demonstrated significant associations between home environment measures (parental policies, role modeling, and accessibility) and MVPA time, healthy food intake score, and "junk" food intake score among preschoolers. Significant associations were found between demographic measures (child age, race, and maternal education/work status) and both physical activity and dietary outcomes. We also found evidence that maternal education/work status modifies the association between one or more of the home food environment subscales and the two dietary intake outcomes. It is notable that the moderating effect of maternal education/work status was limited to dietary outcomes.

As presented above, the home environment is complex, including the physical environment, policies, and role modeled behaviors. The home food environment has been correlated to child obesity-related behaviors in adolescents(11) and preschoolers.(43) Cooke(44) previously demonstrated that more meals eaten together as a family is associated with higher vegetable intake in preschoolers. In our study, the bivariate analyses showed similar findings for "Parental policies in support of family meals" and healthy food intake scores.

However, our finding that maternal education/work status modifies the effect of the home food environment on child dietary intake is notable. The home environment, including parenting strategies, may be even more important in families of low socio-economic status. Families with stronger family meal policies, where the mother was less educated and did not work for pay, exhibited higher child "junk" food intake scores. Although this may seem surprising given the existing literature about family meals and healthful eating practices, one potential reason may be that these families' meals include more soda and sugar sweetened beverages(45, 46) and fast food;(47) however, specific data about the dietary composition of family meals was not collected in our study.

Low parental education levels have been associated with poorer child diet quality(48, 49) and increased child obesity(50). Similarly, maternal employment status (full time, part-time or unemployed) and work hours affect children's healthy lifestyles and the family food environment to varying degrees.(51–54) The moderating effect observed in our study may be due to the effect of SES on the home environment i.e., in homes of mothers with low education who do not work there may be less healthy food available, so decreasing the access to highly palatable "junk" foods, especially soda and sweetened drinks, and role modeling healthy eating is more important for improving child diet quality. An alternative explanation may be that non-working mothers may be able to spend more time with their children, and therefore have more opportunities to role model healthy and unhealthy eating.

While the combination of education/work status allowed us to investigate maternal influence in different subgroups, further research into the interrelationships among maternal education/work status, other socioeconomic factors, the home environment, child behaviors, and ultimately, on child weight, is warranted.

Additional research may also examine the extent to which the influences of the home environment change as the children get older and if (and how) parenting strategies may need to adapt accordingly. Direct reports from both parents are also important to assess the effects of concordant/discordant parenting policies and how differently role modeled behaviors may impact children.

Strengths and Limitations

This study includes a relatively large and diverse sample, a comprehensive measure of the home physical activity and food environment, and objective measurement of physical activity. Limitations include the fact that our participants are from homes with two caregivers, and are somewhat more educated and have higher household incomes than the North Carolina population.[50] These factors may limit the generalizability of our results. The children in this study are all considered higher risk for overweight since the mothers were overweight or obese. The dietary outcomes are based on self-reported measures completed by the mother only. Accelerometer data was not collected at "follow-up 2" which reduced the analysis sample available for physical activity outcomes. The current analyses are cross-sectional and any causal inferences are tentative. We did not adjust for multiple comparisons, so significant associations with p-values close to 0.05 should be interpreted with caution.

CONCLUSION

To promote healthy behavior in young children, strategies emphasizing parental behavior and the set-up of the home environment are warranted. Parental role modeling can be beneficial in reducing "junk" food consumption and sedentary time. Limiting access to unhealthy foods can both increase the amount of healthy food and decrease the amount of "junk" food consumed. To promote physical activity and healthy eating in younger children, strategies emphasizing family policies, especially those around the encouragement of active play and limiting access to unhealthy foods are warranted.

The variable effect of the home environment on health behaviors across different socioeconomic groups is notable: to better prevent and reduce obesity (with healthier physical activity and food behaviors), different strategies may be needed depending on the education and work status of the mother.

Acknowledgments

This study was funded by a grant from the National Institute of Health (NIH), National Institute of Diabetes, Digestive and Kidney Diseases (R01-DK-07549). Dr. Zucker was supported by grant 1-K23-MH-070-418-01. Dr. Fuemmeler was supported by grant 1-K07-CA-124-905-01. The study was approved by the Institutional Review Board of Duke University Health System on 06/14/2008 and is registered with Clinicaltrials.gov (NCT00563264). The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH. Thanks to Ms. Chandima Arambepola for careful editing of this manuscript.

References

1. Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of Obesity and Trends in Body Mass Index Among US Children and Adolescents, 1999–2010. JAMA: The Journal of the American Medical Association. 2012 Feb 1; 307(5):483–90. [PubMed: 22253364]
2. Birch LL, Davison KK. Family Environmental Factors Influencing the Developing Behavioral Controls of Food Intake and Childhood Overweight. Pediatric clinics of North America. 2001; 48(4):893–907. [PubMed: 11494642]
3. Faith MS, Berman N, Heo M, Pietrobelli A, Gallagher D, Epstein LH, et al. Effects of Contingent Television on Physical Activity and Television Viewing in Obese Children. Pediatrics. 2001 May 1; 107(5):1043–8. [PubMed: 11331684]
4. Sallis JF, Prochaska JJ, Taylor WC. A review of correlates of physical activity of children and adolescents. Medicine & Science in Sports & Exercise. 2000; 32(5):963–75. [PubMed: 10795788]
5. Fuemmeler BF, Anderson CB, Masse LC. Parent-child relationship of directly measured physical activity. The International Journal of Behavioral Nutrition and Physical Activity [Report]. 2011 Mar 08.8:17.
6. Anderson CB, Hughes SO, Fuemmeler BF. Parent–child attitude congruence on type and intensity of physical activity: Testing multiple mediators of sedentary behavior in older children. Health Psychology. 2009; 28(4):428–38. [PubMed: 19594267]
7. Hearn MD, Baranowski T, Baranowski J, Doyle C, Smith M, Lin LS, et al. Environmental Influences on Dietary Behavior Among Children: Availability and Accessibility of Fruits and Vegetables Enable Consumption. Journal of Health Education. 1998; 29(1):26–32.
8. Kratt P, Reynolds K, Shewchuk R. The Role of Availability as a Moderator of Family Fruit and Vegetable Consumption. Health Education & Behavior. 2000 Aug 1; 27(4):471–82. [PubMed: 10929754]
9. Cullen KW, Baranowski T, Owens E, Marsh T, Rittenberry L, de Moor C. Availability, Accessibility, and Preferences for Fruit, 100% Fruit Juice, and Vegetables Influence Children's Dietary Behavior. Health Education & Behavior. 2003 Oct 1; 30(5):615–26. [PubMed: 14582601]
10. Boutelle KN, Fulkerson JA, Neumark-Sztainer D, Story M, French SA. Fast food for family meals: relationships with parent and adolescent food intake, home food availability and weight status. Public Health Nutrition. 2007; 10(1):16–23. [PubMed: 17212838]

11. Campbell KJ, Crawford DA, Salmon J, Carver A, Garnett SP, Baur LA. Associations Between the Home Food Environment and Obesity-promoting Eating Behaviors in Adolescence[ast]. Obesity. 2007; 15(3):719–30. [PubMed: 17372323]
12. Neumark-Sztainer D, Wall M, Story M, Fulkerson JA. Are family meal patterns associated with disordered eating behaviors among adolescents? Journal of Adolescent Health. 2004; 35(5):350–9. [PubMed: 15488428]
13. Fiese BH, Hammons A. Grigsby-Toussaint D. Family mealtimes: A contextual approach to understanding childhood obesity. Economics & Human Biology.
14. Brown R, Ogden J. Children's eating attitudes and behaviour: a study of the modelling and control theories of parental influence. Health Education Research. 2004 Jun 1; 19(3):261–71. [PubMed: 15140846]
15. Oliveria S, Ellison R, Moore L, Gillman M, Garrahie E, Singer M. Parent-child relationships in nutrient intake: the Framingham Children's Study. The American Journal of Clinical Nutrition. 1992 Sep 1; 56(3):593–8. [PubMed: 1503074]
16. Dovey TM, Staples PA, Gibson EL, Halford JCG. Food neophobia and 'picky/fussy' eating in children: A review. Appetite. 2008; 50(2–3):181–93. [PubMed: 17997196]
17. Wolfe BL, Behrman JR. Women's schooling and children's health: Are the effects robust with adult sibling control for the women's childhood background? Journal of Health Economics. 1987; 6(3):239–54. [PubMed: 10284621]
18. Ruel MT, Habicht J-P, Pinstrup-Andersen P, Gröhn Y. The Mediating Effect of Maternal Nutrition Knowledge on the Association between Maternal Schooling and Child Nutritional Status in Lesotho. American Journal of Epidemiology. 1992 Apr 15; 135(8):904–14. [PubMed: 1585903]
19. Behrman JR, Wolfe BL. More evidence on nutrition demand: Income seems overrated and women's schooling underemphasized. Journal of Development Economics. 1984; 14(1):105–28.
20. Sherry B, McDivitt J, Birch LL, Cook FH, Sanders S, Prish JL, et al. Attitudes, practices, and concerns about child feeding and child weight status among socioeconomically diverse white, Hispanic, and African-American mothers. Journal of the American Dietetic Association. 2004; 104(2):215–21. [PubMed: 14760569]
21. Gibson EL, Wardle J, Watts CJ. Fruit and vegetable consumption, nutritional knowledge and beliefs in mothers and children. Appetite. 1998; 31(2):205–28. [PubMed: 9792733]
22. Lien N, Jacobs DR, Klepp KI. Exploring predictors of eating behaviour among adolescents by gender and socio-economic status. Public health nutrition. 2002; 5(5):671–81. [PubMed: 12372162]
23. Baughcum AE, Chamberlin LA, Deeks CM, Powers SW, Whitaker RC. Maternal Perceptions of Overweight Preschool Children. Pediatrics. 2000 Dec 1; 106(6):1380–6. [PubMed: 11099592]
24. Heitzler CD, Lytle LA, Erickson DJ, Barr-Anderson D, Sirard JR, Story M. Evaluating a model of youth physical activity. American Journal of Health Behavior. 2010; 34(5):593–606. [PubMed: 20524889]
25. Østbye T, Zucker NL, Krause KM, Lovelady CA, Evenson KR, Peterson BL, et al. Kids and Adults Now! Defeat Obesity (KAN-DO): Rationale, design and baseline characteristics. Contemporary Clinical Trials. 2011; 32(3):461–9. [PubMed: 21300177]
26. Obes Res. 1998. Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults--The Evidence Report. National Institutes of Health; p. 51S-209S.1998/11/14
27. Gattshall M, Ann Shoup J, Marshall J, Crane L, Estabrooks P. Validation of a survey instrument to assess home environments for physical activity and healthy eating in overweight children. International Journal of Behavioral Nutrition and Physical Activity. 2008; 5(1):1–13. [PubMed: 18182102]
28. http://www.fns.usda.gov/wic/
29. Ostbye T, Peterson BL, Krause KM, Swamy GK, Lovelady CA. Predictors of postpartum weight change among overweight and obese women: results from the Active Mothers Postpartum study. J Womens Health (Larchmt). 2012 Feb; 21(2):215–22. [PubMed: 22092110]

NIH-PA Author Manuscript

NIH-PA Author Manuscript

30. Dubois L, Farmer A, Girard M, Peterson K. Regular Sugar-Sweetened Beverage Consumption between Meals Increases Risk of Overweight among Preschool-Aged Children. Journal of the American Dietetic Association. 2007; 107(6):924–34. [PubMed: 17524711]
31. Malik VS, Schulze MB, Hu FB. Intake of sugar-sweetened beverages and weight gain: a systematic review. The American Journal of Clinical Nutrition. 2006 Aug; 84(2):274–88. [PubMed: 16895873]
32. Bowman SA, Gortmaker SL, Ebbeling CB, Pereira MA, Ludwig DS. Effects of fast-food consumption on energy intake and diet quality among children in a national household survey. Pediatrics. 2004; 113(1):112–8. [PubMed: 14702458]
33. Bowman SA, Vinyard BT. Fast Food Consumption of U.S. Adults: Impact on Energy and Nutrient Intakes and Overweight Status. J Am Coll Nutr. 2004 Apr 1; 23(2):163–8. [PubMed: 15047683]
34. Ledoux TA, Hingle MD, Baranowski T. Relationship of fruit and vegetable intake with adiposity: a systematic review. Obesity Reviews. 2010:e143–50.
35. Alinia S, Hels O, Tetens I. The potential association between fruit intake and body weight – a review. Obesity Reviews. 2009; 10(6):639–47. [PubMed: 19413705]
36. Klippel NJ, Heil DP. Validation of Energy Expenditure Prediction Algorithms in Adults Using the Actical Electronic Activity Monitor. Medicine & Science in Sports & Exercise. 2003; 35(5):S284.
37. Puyau MR, Adolph AL, Vohra FA, Butte NF. Validation and Calibration of Physical Activity Monitors in Children. Obesity. 2002; 10(3):150–7.
38. Puyau MR, Adolph AL, Vohra FA, Zakeri I, Butte NF. Prediction of Activity Energy Expenditure Using Accelerometers in Children. Medicine & Science in Sports & Exercise. 2004; 36(9):1625–31. [PubMed: 15354047]
39. Pfeiffer KA, McIver KL, Dowda M, Almeida MJCA, Pate RR. Validation and Calibration of the Actical Accelerometer in Preschool Children. Medicine & Science in Sports & Exercise. 2006; 38(1):152–7. [PubMed: 16394968]
40. Evenson K, Cattellier D, Gill K, Ondrak K, McMurray R. Calibration of two objective measures of physical activity for children. Journal of Sports Sciences. 2008; 26:1557–65. [PubMed: 18949660]
41. Centers for Disease Control and Prevention. CDC Growth Charts. 2010. [cited 2012 December 18]; Available from: http://www.cdc.gov/growthcharts/cdc_charts.htm
42. SAS. Knowledge Base/Product Documentation. 2012. [cited 2012 December 18]; Available from: http://support.sas.com/documentation/92/index.html
43. Hanson NI, Neumark-Sztainer D, Eisenberg ME, Story M, Wall M. Associations between parental report of the home food environment and adolescent intakes of fruits, vegetables and dairy foods. Public Health Nutrition. 2005; 8(01):77–85. [PubMed: 15705248]
44. Cooke LJ, Wardle J, Gibson EL, Sapochnik M, Sheiham A, Lawson M. Demographic, familial and trait predictors of fruit and vegetable consumption by pre-school children. Public Health Nutrition. 2004; 7(2):295–302. [PubMed: 15003137]
45. De Coen V, Vansteelandt S, Maes L, Huybrechts I, De Bourdeaudhuij I, Vereecken C. Parental socioeconomic status and soft drink consumption of the child. The mediating proportion of parenting practices. Appetite. 2012; 59(1):76–80. [PubMed: 22475631]
46. Welsh JA, Sharma AJ, Grellinger L, Vos MB. Consumption of added sugars is decreasing in the United States. The American Journal of Clinical Nutrition. 2011 Sep 1; 94(3):726–34. [PubMed: 21753067]
47. Devine CM, Farrell TJ, Blake CE, Jastran M, Wethington E, Bisogni CA. Work Conditions and the Food Choice Coping Strategies of Employed Parents. Journal of Nutrition Education and Behavior. 2009; 41(5):365–70. [PubMed: 19717121]
48. Campbell K, Crawford D, Jackson M, Cashel K, Worsley A, Gibbons K, et al. Family food environments of 5–6-year-old-children: Does socioeconomic status make a difference? Asia Pacific Journal of Clinical Nutrition. 2002; 11:S553–S61. [PubMed: 12492647]
49. Crawford PB, Obarzanek E, Schreiber GB, Barrier P, Goldman S, Frederick MM, et al. The effects of race, household income, and parental education on nutrient intakes of 9- and 10-year-old girls NHLBI growth and health study. Annals of Epidemiology. 1995; 5(5):360–8. [PubMed: 8653208]
50. Mangrio E, Lindström M, Rosvall M. Early life factors and being overweight at 4 years of age among children in Malmö, Sweden. BMC Public Health. 2010; 10(1):1–9. [PubMed: 20043862]

51. Brown JE, Broom DH, Nicholson JM, Bittman M. Do working mothers raise couch potato kids? Maternal employment and children's lifestyle behaviours and weight in early childhood. Social Science & Medicine. 2010; 70(11):1816–24. [PubMed: 20299142]

52. Bauer KW, Hearst MO, Escoto K, Berge JM, Neumark-Sztainer D. Parental employment and work-family stress: Associations with family food environments. Social Science & Medicine. 2012; 75(3):496–504. [PubMed: 22591825]

53. Morrissey TW, Dunifon RE, Kalil A. Maternal Employment, Work Schedules, and Children's Body Mass Index. Child Development. 2011; 82(1):66–81. [PubMed: 21291429]

54. Anderson PM, Butcher KF, Levine PB. Maternal employment and overweight children. Journal of Health Economics. 2003; 22(3):477–504. [PubMed: 12683963]

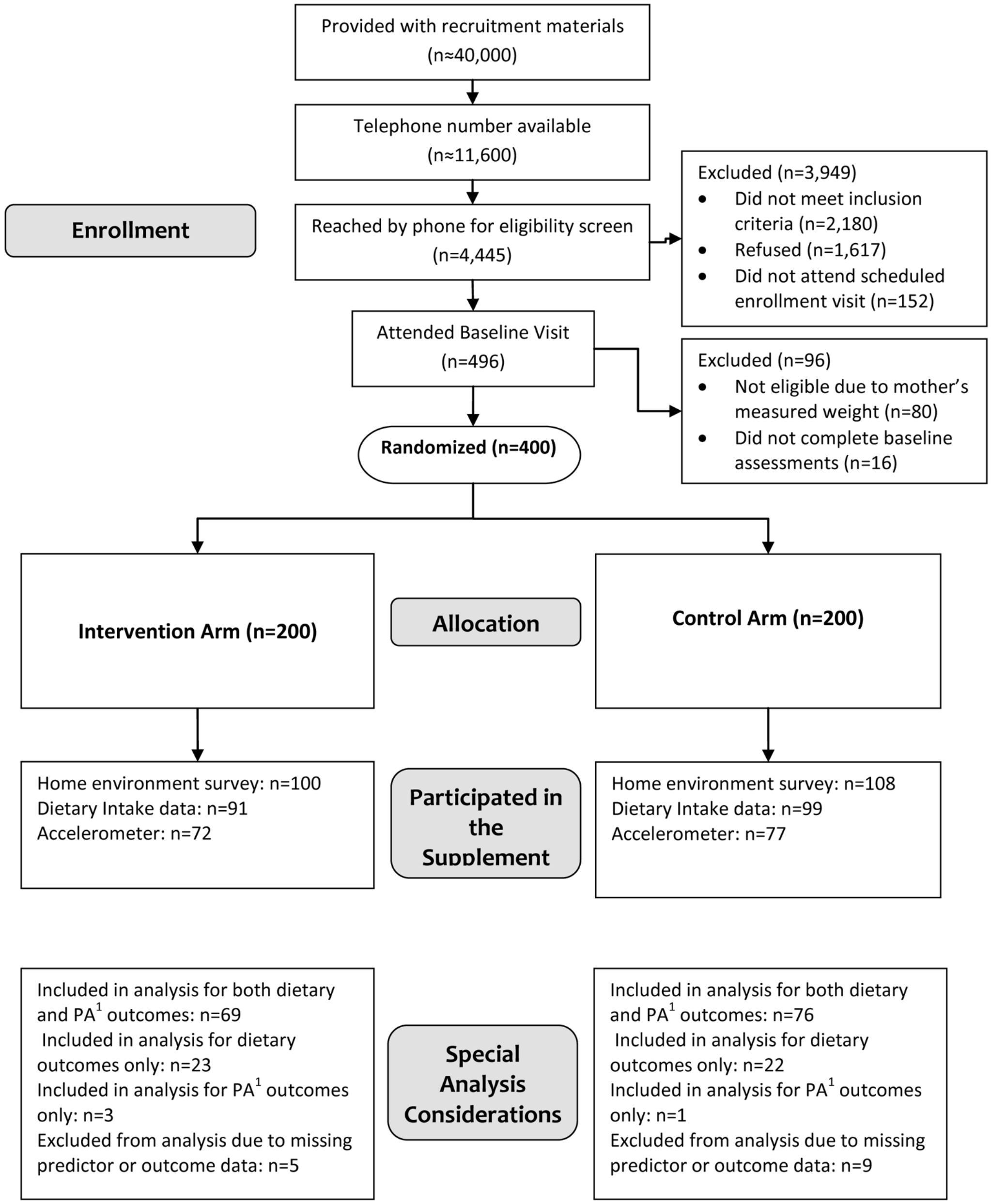

Figure 1. KAN-DO Study CONSORT flow diagram

[1]PA= Physical Activity

Study conducted in the Triangle and Triad regions of North Carolina, U.S.A. 2007–2011.

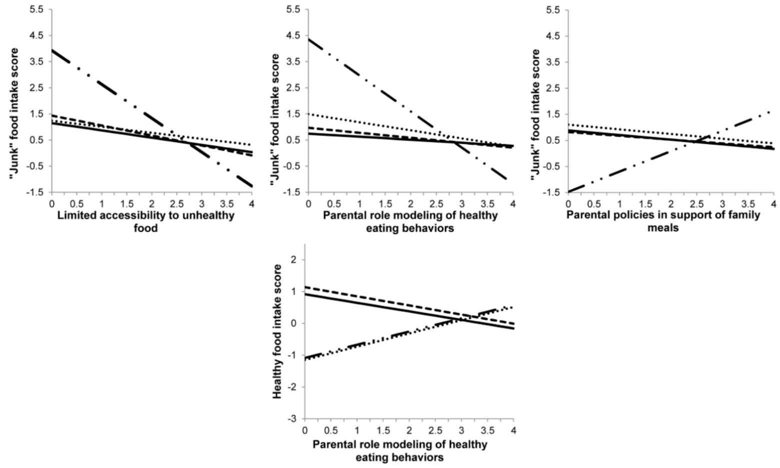

Figure 2. Association of three home food environment subscales, with "junk" food intake score, and of parental role modelling of healthy eating behaviors with healthy food intake score, by maternal education/work status (College & Not working [——], College & Working[– – –], No college & Working [•••••••••] and No college & Not working [▬ • •]

Note: Each graph reflects the score for a child of average age (57.6 months), male, Black, in the control arm, assessed at follow up 1, and with average scores on the two home food environment subscales not represented on the X-axis.

Table 1

Sample Characteristics and Bivariate Associations with MVPA, Sedentary Time, Healthy Food and "Junk" Food Intake Scores

	N=208	MVPA time[a] (n=149)	Sedentary time[b] (n=149)	Healthy food intake score[c] (n=190)	"Junk" food intake score[d] (n=190)
Variable	**% (n)**	**Mean (SE)**	**Mean (SE)**	**Mean (SE)**	**Mean (SE)**
Child Age					
<5 years	55 (114)	15.4 (1.15)*	370.7 (7.91)*	0.11 (0.09)	−0.10 (0.11)
≥5 years	45 (94)	19.5 (1.37)	396.3 (8.57)	−0.14 (0.12)	0.12 (0.09)
Child gender					
Male	56 (116)	18.8 (1.27)	380.0 (8.06)	0.03 (0.10)	0.02 (0.08)
Female	44 (92)	15.7 (1.25)	387.7 (8.66)	−0.04 (0.10)	−0.03 (0.14)
Child race					
Black	13 (28)	18.5 (3.22)	404.3 (20.42)	0.08 (0.18)	0.49 (0.17)*
White/other	87 (180)	17.3 (0.93)	380.3 (6.06)	−0.01 (0.08)	−0.08 (0.08)
Child weight status at supplement					
BMI <85th percentile	75 (155)	18.0 (1.09)	378.8 (6.37)	0.05 (0.08)	−0.05 (0.09)
BMI ≥ 85thpercentile	25 (53)	15.8 (1.57)	397.2 (13.81)	0.00 (0.16)	0.14 (0.12)
Maternal education/work status (n=205)					
No college education/Not working	15 (31)	16.3 (1.73)	355.6 (13.84)	−0.16 (0.20)	0.48 (0.38)
College education/Not working	27 (57)	16.4 (1.55)	375.07 (11.21)	−0.03 (0.14)	−0.20 (0.10)
No college education/Working	10 (21)	13.1 (2.95)	431.28 (24.98)	−0.33 (0.21)	0.23 (0.16)
College education/Working	46 (96)	19.0 (1.40)	386.23 (7.83)	0.13 (0.10)	−0.09 (0.07)
Study arm					
Intervention	48 (100)	17.4 (1.29)	391.8 (8.63)	0.02 (0.10)	−0.09 (0.07)
Control	52 (108)	17.5 (1.28)	375.5 (8.03)	−0.02 (0.10)	0.07 (0.12)

MVPA - moderate-to-vigorous physical activity; SE – standard error

[a]based on accelerometry (mean = 17.5 minutes per day, SE = 0.90)

[b]based on accelerometry (mean = 383.0 minutes per day, SE = 5.83)

[c]Mean healthy food factor score = 0.00, SE = 0.07

[d]Mean "junk" food factor score = −0.01, SE = 0.07

* $p < .05$

NIH-PA Author Manuscript
NIH-PA Author Manuscript

Table 2

Bivariate Correlations of Home Environment Scales and Physical Activity and Dietary Intake Outcomes

Home environment scales	MVPA time (n=149)	Sedentary time (n=149)	Healthy food intake score (n=190)	"Junk" food intake score (n=190)
Home physical activity environment				
Accessibility of physical activity equipment	0.01	−0.08		
Role modeling of physical activity	0.12	−0.06		
Parental policies in support of physical activity	0.26*	−0.04		
Home food environment				
Limited access to unhealthy foods			0.24*	−0.44*
Role modeling of healthy eating behaviors			0.05	−0.30*
Parental policies in support of family meals			0.17*	−0.15*

MVPA - moderate-to-vigorous physical activity

* $p < 0.05$

Table 3a

Physical activity outcomes (n=149)

Variable	MVPA time[a]			Sedentary time[a]		
	β coefficient (SE)	p-value	Std. β coefficient	β coefficient (SE)	p-value	Std. β coefficient
Intercept	−4.08 (11.01)	0.71	0.0	7.29 (55.01)	0.89	0.0
Child age[b]	0.25 (0.08)	0.001	0.3	0.36 (0.38)	0.35	0.1
Child gender (male)	2.54 (1.71)	0.14	0.1	−10.02 (8.56)	0.24	−0.1
Child race (black)	−0.34 (2.67)	0.90	0.0	13.66 (13.32)	0.31	0.1
Child BMI[b]	−0.77 (0.46)	0.10	−0.1	1.10 (2.30)	0.63	0.0
Arm (intervention)	−0.05 (1.71)	0.98	0.0	6.78 (8.55)	0.43	0.0
Supplement timepoint (FU1)[d]	−4.92 (1.85)	0.01	−0.2	11.57 (9.26)	0.21	0.1
Mother- College education and Not currently working[c]	0.88 (3.08)	0.78	0.0	33.23 (15.37)	0.03	0.2
Mother- No college education and Working[c]	−3.61 (3.86)	0.35	−0.1	74.53 (19.26)	0.0002	0.3
Mother- College education and Working[c]	3.29 (2.87)	0.25	0.1	28.98 (14.36)	0.05	0.2
Home physical activity environment						
Accessibility of physical activity equipment[b]	0.14 (1.41)	0.92	0.0	−4.34 (7.03)	0.54	0.0
Role modeling of physical activity[b]	−0.02 (1.35)	0.99	0.0	−11.31 (6.73)	0.10	−0.1
Parental policies in support of physical activity[b]	2.77 (1.31)	0.04	0.2	−7.33 (6.57)	0.27	−0.1
R^2	*0.24*			*0.55*		

BMI: Body mass index; FU: Follow up; MVPA - moderate-to-vigorous physical activity; SE - standard error

[a] Also adjusted for accelerometer wear-time

[b] Used as a continuous variable in these analyses

[c] Reference is 'Mother- No college education and Not currently working'

[d] FU1 = immediate post-intervention visit, FU2 was ~12 months later

Table 3b

Dietary intake outcomes (n=190)

	Healthy food intake score			"Junk" food intake score		
Variable	**β coefficient (SE)**	**p-value**	**Std. β coefficient**	**β coefficient (SE)**	**p-value**	**Std. β coefficient**
Intercept	−2.02 (0.75)	0.01	0.0	5.17 (0.85)	<.0001	0.0
Child age[a]	−0.01 (0.01)	0.17	−0.1	0.00 (0.00)	0.52	0.0
Child gender (male)	0.12 (0.14)	0.38	0.1	0.12 (0.11)	0.27	0.1
Child race (black)	0.18 (0.22)	0.41	0.1	0.58 (0.18)	0.001	0.2
Arm (intervention)	−0.06 (0.14)	0.68	0.0	−0.04 (0.11)	0.70	0.0
Supplement timepoint (FU1)[d]	0.14 (0.15)	0.36	0.1	0.20 (0.12)	0.09	0.1
Mother- College education and Not currently working[b]	2.00 (0.74)	0.01	0.9	−3.77 (1.05)	0.0004	−1.7
Mother- No college education and Working[b]	−0.06 (0.29)	0.83	0.0	−3.15 (1.03)	0.003	−1.0
Mother- College education and Working[b]	2.22 (0.65)	0.001	1.2	−3.36 (0.92)	0.0004	−1.7
Home food environment						
Limited access to unhealthy foods[a]	0.24 (0.09)	0.01	0.2	−1.30 (0.19)	<.0001	−1.0
Role modeling of healthy eating behaviors[a]	0.42 (0.16)	0.01	0.3	−1.38 (0.18)	<.0001	−0.98
Parental policies in support of family meals[a]	0.19 (0.13)	0.15	0.1	0.78 (0.24)	0.001	0.5
Interaction effects[c]						
Limited unhealthy food availability x College/Not working				1.02 (0.22)	<.0001	1.3
Limited unhealthy food availability x No college/Working				1.07 (0.28)	0.0002	0.9
Limited unhealthy food availability x College/Working				0.92 (0.22)	<.0001	1.3
Role modeling x College/Not working	−0.68 (0.25)	0.01	−0.9	1.26 (0.24)	<.0001	1.7
Role modeling x No college/Working				1.07 (0.26)	<.0001	1.0
Role modeling x College/Working	−0.70 (0.23)	0.002	−1.0	1.19 (0.22)	<.0001	1.7
Parental policies x College/Not working				−0.96 (0.34)	0.01	−1.2
Parental policies x No college/Working				−0.96 (0.33)	0.01	−0.7
Parental policies x College/Working				−0.93 (0.28)	0.001	−1.2
R^2	*0.18 (model without interaction: 0.12)*			*0.55 (model without interaction: 0.34)*		

FU: Follow up; SE – standard error;

[a]Used as a continuous variable in these analyses

[b]Reference is 'Mother- No college education and Not currently working'

[c]Only significant interaction terms were retained

[d]FU1 = immediate post-intervention visit, FU2 was ~12 months later