

ORIGINAL RESEARCH

Food Intake Compared to Exercise Association with Obesity in Children Ages 3–6

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Background: Childhood obesity affects 19.3% of children ages 2 to 19 years in the US, and 25.6% of Hispanic children. Study objectives were to (1) assess the feasibility of monitoring physical activity and daily caloric intake in children ages 3 to 6 years, (2) assess whether known obesity risk factors apply to this age-group, and (3) explore the factors that may contribute to the higher prevalence of obesity in Hispanic preschooler.

Methods: Children ages 3 to 6 years were recruited at well child visits (n = 37, 65% male, 30% Hispanic). Parents completed a questionnaire (child's physical activity and screen time) along with a detailed dietary assessment. Children were provided with a fitness tracker worn for 5 days. Fisher's exact test, t test/Wilcoxon rank sum tests were conducted.

Results: Thirty-four (92%) participants produced usable activity data. Baseline dietary recall was completed by 35 (97%) of the parents and 25 (68%) completed the second unassisted dietary recall. Mean body mass index of the study sample was 60th percentile, 12 (32%) classified as overweight/obese. Children with overweight/obesity showed no significant difference in mean daily calories compared with those without (1403.9 vs 1406.1 Kcal/day, $P = .980$) or daily hours of screen time (1.5 ± 1.1 vs 1.7 ± 0.8 , $P = .442$). Children with overweight/obesity had fewer mean daily steps compared with those without overweight/obesity (8038 ± 2685 vs 10038 ± 2599 , $P = .051$).

Discussion: Findings indicate that pedometer activity tracking can be used in children 3 to 6 years old and that decreased physical activity correlates more closely to preschool overweight/obesity than caloric intake. (J Am Board Fam Med 2022;00:000–000.)

Keywords: Child Health, Exercise, Fitness Trackers, Nutrition Assessment, Pediatric Obesity, Screen Time, Surveys and Questionnaires

Introduction

With 42.4% of American adults having obesity, obesity is a major issue in the United States.¹ Among youth in the United States age 2 to 19 years old 19.3% are affected or approximately 14.4 million.² Children 2 to 5 years old have a 13.4% prevalence.² Children with obesity are more likely to

have obesity in adolescence and as adults. Hispanic children are at the highest risk of obesity of all preschool-aged children.³ Among children ages 2 to 19, the prevalence of obesity among Hispanic children is 25.6% compared with 19.3% for the general population. Multiple factors are associated with pediatric obesity, including socioeconomic status, genetics, parental lifestyle and feeding behavior, dietary factors including consumption of sugary beverages, screen time, physical activity, and environmental factors such as neighborhood safety.^{4–7} A 2015 review of studies on obesity in Hispanic preschool aged children identified 3 categories of factors frequently associated with obesity: maternal factors (feeding practices, beliefs, and values), environmental factors (family, socioeconomic status, and acculturation) and child behavior (physical activity and screen time).⁴ Parent, day care and preschool 3

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to 6 year olds offer opportunities for behavior interventions that are not available with older children. Unfortunately, parents often are not good judges of their child's weight status. One study found mothers much more accurate in perceiving their own obesity as opposed to their child's (94% vs 42%).⁸ A systematic review including 11,530 children who were overweight found that 62.4% of parents perceived them as having normal weight.⁹ Another study found only 7% of parents of overweight children considered their child to be overweight.¹⁰

Cultural factors have been identified by multiple studies as a barrier to successful dietary and physical activity interventions.¹¹⁻¹³ A study tracking the location and physical activity of Hispanic American preschool children using the Global Positioning System (GPS) data loggers and an accelerometer found that activity changed by location, with participants being more active in parks and less active at home.¹⁴ Research into physical activity of children is a growing area of interest. Most objective studies have used accelerometers; however no consensus has been reached what constitutes a normal activity level as measured by an accelerometer for children aged 3 to 6 years old.¹⁵⁻¹⁸ Pedometer step counts have been found to correlate with accelerometer activity levels providing a less expensive method to track physical activity in children.^{12,13,19} The CANPLAY study provides population representative pedometer data for 5 to 19 year olds.²⁰ There is good evidence that physical activity in children 6 and older is negatively associated with z-score BMI, but very little data on preschoolers.²¹

Our study combined assessment of physical activity and daily caloric intake and their relationship to obesity in children ages 3 to 6 years in a rural clinical setting. In addition, we looked at parental perception of weight, diet and physical activity level to see how well these correlated with measured values.

Methods

Institutional review board approval was obtained for this cross-sectional study. Subjects were recruited from a 4 (2.8 full-time equivalent (FTE)) provider outlying family medicine clinic affiliated with a tertiary health care system in the Midwest. The clinic serves a rural population with Hispanics making up 30 to 40% of that clinic population with

approximately 290 pediatric visits per month of which 49 visits are 3-to-6-year-olds. Before the study BMI percentile data were pulled from the institution's electronic medical record, Epic (Verona, WI) for all children ages 2 through 5 years seen at the study clinic from 2009-18 (n = 199). BMI percentile of those who identified as Hispanic (mean = 61.7, SD = 31.7) was significantly greater than those who identified as non-Hispanic (mean = 57.6, SD = 31.4) ($P < .001$). A chi-square test of independence was performed to compare the proportion of those above the 85th BMI percentile. This showed a significant association between the proportion of children with overweight/obesity and ethnicity (Hispanics 33%, non-Hispanics 25%, $P < .001$).

All children ages 3 to the end of their 6th year were eligible for the study. Information including study purpose, inclusion criteria, surveys, wearing the tracker, and compensation was sent to parents of children who had an upcoming well child visit during the summer of 2019. A telephone call was made to gauge study interest a week after the mailing by the medical student researcher (TS). On the day of their clinic appointment, staff informed parents with appropriately aged children about the study. Those interested in participating were directed to TS following completion of their scheduled appointment.

In a private room in the clinic, the researcher explained the mechanics of the study and reviewed the informed consent document in English or Spanish according to the parent's (or legal guardian's) preference. The study included an investigator-developed parental perception questionnaire, 5 consecutive days of wearing an activity tracker, 24-hour validated dietary survey at the time of enrollment and again on the final day of wearing the activity tracker and allowing the researcher access to the child's medical record. Compensation of \$20 was provided for returning the pedometer.

Parental Questionnaire

After reviewing the literature for proposed causes and/or risk factors for pediatric obesity, the investigators developed a questionnaire consisted of 18 questions. Topics included family demographics, child's feeding as an infant, and parent's perception of the child's relative weight, eating habits, and physical activity. Two questions were open ended, asking about factors parents believed affected their

child's weight or would make a healthy weight more achievable. A complete list of questions may be viewed in the Appendix.

Automated Self-Administered 24-Hour (ASA24)

Dietary Assessment Tool

The ASA24 is a free web-based tool from the National Institutes of Health National Cancer Institute that translates a 24-hour diet recall into food group and nutrient data.²¹ It is available in both English and Spanish. The research assistant aided the child's guardian through 24-hour recall and the guardian was asked to complete another 24-hour recall 5 days later at home. It took about 20 minutes for the parent to complete. Information collected included: what was eaten, how much, and which meal each food was consumed with. The food item information in the program is quite detailed and specific. For example, if a chicken drumstick is entered the following questions are generated: Whether the drumstick has skin? Was the skin eaten? Was it coated? How was it cooked? How much of it did the child eat? The database has 7000 food list terms with 4400 photographs representing food portions. Data output includes a person's individual level nutrient and food group estimates.²² The instrument has been validated compared with a similar semiquantitative food frequency questionnaire and an interview-administered survey.^{23,24}

Physical Activity

The child's physical activity was assessed through 5 days of tracking with the Garmin Vívofit Jr. 2 fitness tracker, a child size version with a year-long battery life. The Vívofit Jr can measure steps, distance, calories burned, active minutes and sleep. Using the Vívofit Jr 2 software application information was recorded for the study. Eleven trackers at \$55 each were purchased for the study and participants were enrolled during a 10-week period in the summer of 2019. After subjects had completed their 5 days of wearing the trackers, the trackers were mailed back to the researchers and the data downloaded. Only 1 tracker was not returned. Sleep data for the tracker was not recorded.

The Garmin Vívofit Jr. 2 was chosen because of its appeal to kids and the long battery life (no need to recharge). Some children may have been more compliant with a thinner band like the Fitbit Flex 2.

For future studies connecting the activity tracker to a smartphone web app like "Garmin Connect" with "Livetrack" would simplify obtaining the data.

Medical Record

Demographic and biometric information collected from the clinic's electronic medical record included age, race, ethnicity, gender, height, and weight.

Weight Categories

A BMI percentile was calculated using the Centers for Disease Control and Prevention (CDC) Child & Teen BMI Calculator (<https://www.cdc.gov/healthyweight/bmi/calculator.html>). The subjects were then divided into 2 groups: without overweight/obesity (<85th percentile: CDC Categories 1 and 2), and with overweight/obesity (≥85th percentile: CDC Categories 3 and 4).

Statistical Analysis

Questionnaire data, demographic data from medical record review, and BMI percentiles were entered into an Excel spreadsheet and along with the ASA24 dietary information and the Garmin Vívofit Jr. 2 application data. Descriptive statistics were computed for all demographic and study variables. To compensate for differing caloric needs depending on age, sex, and activity level, in addition to daily calories, we calculated percent of estimated calorie needs per day by age, sex, and activity level. We used the CANPLAY pedometer data to define level of activity with the bottom quintile being sedentary, the mid 3 quintiles moderate activity and the top quintile active. Children without overweight/obesity and children with overweight/obesity were used as an outcome variable. Categorical variables were compared between the 2 groups using a Fisher's exact test. Continuous variables were compared using a *t* test or Wilcoxon rank sum as appropriate. Spearman's *r* was used to correlate parental perception of their child's physical activity with actual step count. All analyses were performed using SPSS (Version 26.0; IBM Corp., Armonk, NY).

Results

Parents of 37 children gave written, informed consent. The mean age of subjects was 4.6 years (S.D. 1.2 years). Twenty-four (65%) were male. Ten (27%) were Hispanic; 24 (65%) were White, 2

(5%) were Black, and 1 (3%) was multiracial. Raw BMI ranged from 13 to 24 with a mean BMI of 16.8. BMI percentiles ranged from fourth to 99th with a mean of 60th percentile. One child (3%) was classified as underweight, 23 (65%) as healthy weight, 5 (14%) as overweight, and 7 (19%) as having obesity. Six of the 7 children with obesity were above the 99th percentile for BMI percentile (Table 1).

Thirty (81%) of the children wore the trackers for 5 days and 4 (11%) wore the tracker for 4 days. Two children did not record any meaningful activity data and 1 activity tracker was not returned. The range for number of steps taken daily was 4205 to 14,551 with a daily average of 9450 steps. Parents for 36 (97%) of the children completed the 24-hour food diary at baseline and 24 (65%) completed the second 24-hour food diary recall at home. Average daily calorie intake at baseline was 1375 calories with a range of 506 to 2446 calories. Average daily calorie

intake for the concluding 24-hour food diary recall was 1440 with a range of 827 to 2098 calories.

Parents for 33 (89%) children perceived their child as having a healthy weight and 3 (8%) perceived their child as being overweight. None of the parents thought their child was obese. Parental perception of the quantity of food eaten by their child was reported as adequate by 36 (97%); 30 (81%) perceived the nutritional quality of food as good/excellent. Parental perception of their child's physical activity correlated poorly with Pedometer recorded step count ($r_s = 0.128$). On average 2 meals were eaten out per week, and children spent 1.6 hours per day in front of a screen (Table 2).

There was no association between screen time, mom's age at child's birth, and number of nonhome cooked meals eaten per week and the child's BMI category or ethnicity. Children without overweight/obesity and children with overweight/obesity showed no significant difference in mean daily calories, mean daily calories adjusted for height, or mean daily calories adjusted for age, sex, and physical activity level. The children without overweight/obesity averaged more daily steps compared with the children with overweight/obesity, very close to reaching statistical significance ($10,038 \pm 2599$ vs 8038 ± 2685 , $P = .051$). Comparisons between Hispanics and non-Hispanics showed no significant difference in the proportion of children without overweight/obesity and children with overweight/obesity, and in mean daily steps. Hispanics reported consuming fewer daily calories adjusted for height than non-Hispanics (Table 3).

The open-ended text data show parents identified genetics, physical activity, and eating habits as the categories with the greatest impact on their child weight. Action that would make it easier for their children to maintain a healthy weight included: facilitating physical activity, increasing availability of healthy food, and parents having more control over their time so they can spend it with their children/family.

Discussion

Our study had 4 principal findings. The vast majority of the 3 to 6-year-old children in our study recorded useable data from their pedometers. The dietary survey revealed no significant difference in the calories consumed by children with overweight/obesity versus children with normal weight. The

Table 1. Demographic Characteristics of Children and Parents Based on the Medical Record

Characteristics	Results, n (%)
Children	
Age (n = 37)	
3 years	9 (24.3)
4 years	7 (18.9)
5 years	10 (27.0)
6 years	11 (29.7)
Mean = 4.6 (SD = 1.2)	37 (100)
Sex (n = 37)	
Male	24 (64.9)
Female	13 (35.1)
Race (n = 37)	
Black	2 (5.4)
Hispanic of undetermined race	10 (17.0)
White	24 (64.8)
Multiracial	1 (2.7)
Ethnicity (n = 37)	
Hispanic	11 (29.7)
Non-Hispanic	26 (70.3)
Parent's Demographics	
Education mother (n = 31)	
High school or less	12 (38.7)
College or more	19 (61.3)
Education father (n = 26)	
High school or less	12 (46.2)
College or more	14 (53.8)
Mean (SD), Range	
Mother's age at time of child's birth	27.9 (4.8), 17–40

Abbreviations: SD, standard deviation.

Table 2. Parental Perceptions of Child’s Weight, Nutritional Quantity/Quality, Physical Activity, Body Mass Index, and Calories and Steps Per Day

Parental Perception	n (%)
Child’s weight (n = 37)	
Underweight	0
Healthy	33 (89.2)
Overweight	3 (8.1)
Obese	0
No answer	1 (2.7)
Amount of food child eats (n = 37)	
Inadequate	0
Adequate	36 (97.3)
Excessive	1 (2.7)
Nutritional quality of food child eats (n = 37)	
Poor	0
Fair	7 (18.9)
Good	24 (64.9)
Excellent	6 (16.2)
Child’s physical activity level (n = 37)	
Inadequate	1 (2.7)
Adequate	25 (67.6)
Excessive	10 (27.0)
No response	1 (2.7)
Safe areas near home to play outside (n = 37)	
Yes	37 (100)
No	0
Age-adjusted BMI percentile categories (n = 37)	
Underweight (<5th percentile)	1 (2.7)
Healthy (5th percentile to <85th percentile)	24 (64.9)
Overweight (85th percentile to <95th percentile)	5 (13.5)
Obese (≥95th percentile)	7 (18.9)
BMI percentile (n = 37)	60.2 (31.5) 4 to 99
Mean (Range)	
Non-home cooked meals eaten per week (n = 36)	2 meals (0 to 4 meals)
Hours per day child spends in front of a screen (computer, TV, phone, tablet) (n = 37)	1.6 hours (0 to 4 hours)
Steps per day (n = 34) ¹	9450 (4205 to 14551)
Calories per day ²	1405 (732 to 2186)
Day 1 average (n = 36)	1375 (506 to 2446)
Day 2 average (n = 24)	1440 (827 to 2098)

Abbreviation: BMI, body mass index.

¹Average of 4 days or 5 days of step count as measured by Garmin Vivofit Jr. 2.

²As measured by average of calories from ASA24 dietary recall surveys.

daily step count for the group with overweight/obesity was 2000 less than the group with normal weight which was nearly statistically significant ($P = .051$). Parents of children with overweight/obesity uniformly underestimated their child’s weight status. The fact that activity trackers can be used by most children ages 3 to 6 years (in our study 91%), opens the possibility of using pedometers as a

diagnostic tool and for monitoring the effect of interventions focused on increasing physical activity.

Our sample found that parental reported daily caloric consumption was almost identical between children without overweight/obesity and children with overweight/obesity. We were concerned that differences in daily calories could be hidden by confounding factors, specifically varying caloric needs

Table 3. Comparison of Variables in Children by Obesity Status and by Ethnicity Non-Hispanic Column for Ease of Understanding

Variable	Children without Overweight/obesity ¹ n (%)	Children with Overweight/obesity ² n (%)	<i>P</i> value ³	Non-Hispanic n (%)	Hispanic n (%)	<i>P</i> value ³
Ethnicity (n = 37)						
Hispanic	5 (20%)	6 (50%)	0.062 ⁴			
Non-Hispanic	20 (80%)	6 (50%)				
	Mean (SD)	Mean (SD)		Mean (SD)	Mean (SD)	
Daily step average (n = 34)	10038 (2599)	8038 (2685)	0.051	9264 (2832)	9964 (2566)	0.520
Calories/day (n = 36)	1429 (387)	1369 (492)	0.980	1527 (401)	1127 (319)	0.009 ⁵
Calories/cm height/day (n = 36)	12.8 (3.54)	12.8 (4.94)	0.990	13.9 (3.96)	10.24 (2.73)	0.008
Percent of expected calories consumed/day controlled for age, and sex ⁶ (n = 36)	101 (27)	95 (29)	0.521	105 (27)	83 (21)	0.038
Percent of expected calories consumed/day controlled for age, sex and activity level ⁷ (n = 36)	106 (31)	110 (36)	0.750	113 (32)	90 (28)	0.065
Non-home cooked meals/week (n = 36)	2.02 (0.99)	1.36 (1.10)	0.079	1.96 (1.04)	1.38 (1.07)	0.146
Mom's Age at Child's Birth (n = 35)	28.52 (5.39)	26.75 (3.17)	0.304	28.7 (4.63)	26.2 (4.83)	0.149
Parental estimate of screen time/day (n = 37)	1.74 (0.78)	1.50 (1.07)	0.270 ⁵	1.62 (0.57)	1.78 (1.39)	0.811 ⁵

Abbreviations: BMI, body mass index; SD, standard deviation.

¹Age-adjusted BMI percentile < 85th percentile.

²Age-adjusted BMI Percentile ≥ 85th percentile.

³*P* value refers to t test statistic unless otherwise marked.

⁴Fisher exact test.

⁵Wilcoxon ranked sum used due to nonnormal distributions.

⁶Based on US Department of Agriculture (USDA) recommendations controlling for age and sex: (Actual Intake – Expected Intake)/Expected Intake × 100.

⁷Based on USDA recommendations controlling for age, sex, and activity level: (Actual Intake – Expected Intake)/Expected Intake × 100.

among children due to age, sex, height, or level of physical activity. However, no difference was found between the 2 groups when controlling for height (calories/day/cm) ($P=.996$), nor after controlling for age, and sex ($P=.521$) or age, sex, and physical activity level ($P=.750$). This contradicts previous studies. An analysis of NHANES data suggest that preschoolers with overweight/obesity consume more calories than their normal weight peers.²⁵ A much larger study would be needed to confirm a lack of correlation between calories consumed and obesity in preschoolers.

Age and sex adjusted percent of expected calories consumed per day was lower for the Hispanic than the non-Hispanic children (–16.7% vs 5.23%, $P=.0380$) which is constraintuitive as 55% of the enrolled Hispanic children were in the overweight/obese group versus 23% for the non-Hispanic children. Possible explanations for this include the small sample size or cultural differences in how

parents fill out the dietary questionnaire. Our parental perception questionnaire confirmed what other studies have shown: Parents are not good judges of their children's weight, dietary intake, or activity level. Among parents of children with overweight/obesity, 9 (75%) labeled their child as healthy. The 3 (25%) who marked their child as overweight (not obese) had BMIs above the 99th percentile, still underestimating their child's weight status. This underscores the need for effective interventions to improve parental assessment of their child's weight status. Future research might investigate whether parents truly are poor judges, or if they feel they lack agency to change their child's weight status. In addition, a more nuanced question that avoided the value laden term “obese,” such as a 1 to 10 Likert scale might find a better correlation between parental perception and child's weight status.

Our study supports further research on the relationship between physical activity and obesity in

the preschool age children. Research in children between 12 to 24 months old found no association between z-score BMI and achieving physical activity guidelines of 180 minutes per day.²⁶ In children 6 and older, 72% of studies in a systemic review found increased daily steps negatively associated with adiposity.²⁷ A recent large European cohort of 6 to 11-year-olds replicated the negative relationship between z-score BMI and physical activity.²⁸ For preschoolers, 1 study found no relationship between steps and z-score BMI, however it only looked at activity during school.²⁹ A study of 224 preschoolers in Saudi Arabia found higher steps in nonobese (7065 vs 5375) however this was not statistically significant.³⁰ Perhaps the question is what age does physical activity, as measure by step count, begin to correlate negatively with obesity? If confirmed, 1 still needs to determine if decreased activity is a cause of obesity, or a result of it, as suggested by the inverse causality hypothesis.³¹

The main limitation of our study was it lacked an adequate sample size, a common shortcoming of a “summer medical student research project.” This limited our assessment of factors contributing to obesity and precluded us from exploring factors contributing to the greater prevalence of pediatric obesity in Hispanics youth. Another limitation is the questionable accuracy of parental dietary recall. Dietary assessment in the preschool-aged child is difficult. Parents often do not know how much or even what their preschooler has eaten because they were not present at mealtime. The “Automated Self-Administered 24-Hour (ASA24) Dietary Assessment Tool” is labor and time intensive and hasn’t been validated in this age-group. We had significant difficulty getting parents to fill out the second dietary survey. The majority required phone call reminders, and even then, only 24 of 37 completed the second dietary recall. Conducting the second survey in person would help to obtain more complete data. Another option would be complementing the survey with a photographic dietary assessment like “PlateMate.”³²

Conclusion

A high percentage of young children wore their Garmin trackers making activity tracking in children aged 3 to 6 years a feasible research or clinical option. Step count is measurable and because it is a simple number, parents and/or providers can set

target, especially for the less active preschoolers. The daily steps taken by children without overweight/obesity was nearly statistically significantly higher than the steps taken by children with overweight/obesity (10038 vs 8038, $P = .051$).

Future directions include a combined diet and activity intervention trial. Activity data will be shared by parents with their provider via smart phone apps (both Fitbit and Garmin have these). Diet assessment will be more focused. The baseline data can be used to evaluate if preschoolers with overweight/obesity have lower daily step counts compared with their peers with normal weight. Longitudinal data can help evaluate different interventions to increase activity. A much larger trial would help define at what age increased physical activity is associated with decreased z-score BMI.

To see this article online, please go to: <http://jabfm.org/content/35/6/000.full>.

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Appendix

Primary Caregiver Perception Survey

1. What was the age of the mother at the birth of the child? _____
2. What are the highest education levels completed by the child's parents? Mother _____
Father _____
3. How many children are in the home? _____
4. Where does this child fall in the order (e.g., 3rd born of 5 children)? _____
5. How old was your baby when you started breast feeding? _____ months
6. How old when you stopped breast feeding? _____ months
7. How old was your baby when you started bottle feeding? _____ months
8. How old when you stopped bottle feeding? _____ months
9. If you did both which was primary? Breast or bottle? If both breast and bottle were used at the same time, why did you want to use both?
10. How would you describe your child's weight status? (Circle one) Underweight Healthy Overweight Obese
11. How would you describe the amount your child eats? (Circle one) Inadequate Adequate Excessive
12. How would you describe the nutritional quality of the food your child eats? (Check one)
 Poor (mostly sweets or junk food)
 Fair (healthy foods but not enough variety with too much junk food)
 Good (healthy foods but not enough variety)
 Excellent (balanced health foods)
13. How many of your child's meals per week are not home-cooked? _____
14. How would you describe your child's physical activity level? (Circle one) Inadequate Adequate Excessive
15. How many hours a day does your child spend in front of a screen (e.g., computer, TV, phone, tablet)? _____
16. Are there safe areas in the neighborhood for your child to play (e.g., parks, yards)? Yes ___
No ___
17. What other factors do you think affect your child's weight status?
18. What changes would make it easier for your child to be healthier?