HHS Public Access

Author manuscript

J Phys Act Health. Author manuscript; available in PMC 2017 July 01.

Published in final edited form as:

J Phys Act Health. 2016 July ; 13(7): 726–732. doi:10.1123/jpah.2015-0534.

Physical Activity States of Preschool-Aged Latino Children in Farmworker Families: Predictive Factors and Relationship with BMI Percentile

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Abstract

BACKGROUND—Obesity disproportionately affects children of Latino farmworkers. Further research is needed to identify patterns of physical activity (PA) in this group and understand how PA affects Body Mass Index (BMI) percentile.

METHODS—244 participants ages 2.5–3.5 in the Niños Sanos longitudinal study wore accelerometers that measured daily PA. Several PA-related parameters formed a profile for conducting hidden Markov modeling (HMM), which identified different states of PA.

RESULTS—Latino farmworker children were generally sedentary. Two different states were selected using HMM – less active and more active. In the more active state; members spent more minutes in moderate-vigorous physical activity (MVPA). Most children were in the less active state at any given time; however, switching between states occurred commonly. One variable - mother's concern regarding lack of PA – was a marginally significant predictor of membership in the more active state. State did not predict BMI or weight percentile after adjusting for caloric intake.

CONCLUSION—Most children demonstrated high amounts of sedentary behavior, and rates of MVPA fell far below recommended levels for both states. The lack of statistically significant results for risk factors and PA state on weight-related outcomes is likely due to the homogeneous behaviors of the children.

Keywords

Body mass index; accelerometer; childhood obesity; migrant worker; hidden Markov modeling

INTRODUCTION

Childhood obesity is a nationwide problem in the United States, but some groups of Americans, including Latinos, are disproportionately affected. In the 2011–2012 NHANES study, 8.4% of all children ages 2–5 met criteria for obesity; for Latino children in this age

group, the rate was 16.7%.[1] Children of Latino farmworkers may have even greater risk. One study found 27% of children ages 3–16 in this group were obese,[2] while another found 41% of a sample of 6–11 year-old children in migrant farmworker families were overweight or obese.[3]

The disparity in increased risk of obesity among children of Latino farmworkers is likely multifactorial. Although hereditary and metabolic traits may predispose to weight gain,[4] other characteristics, such as environment, socioeconomic status, and cultural beliefs; are of greater importance.[5] As an example, many farmworkers reside in rural areas without properly maintained streets and sidewalks and safe spaces for outdoor play, leading some parents to restrict physical activity.[6, 7] Also, many Latino farmworkers lack documentation required for legal residence in the United States,[8] and migrant families may move frequently between states.[3] Therefore, some parents are reluctant or unable to access government programs intended to provide children with adequate nutrition and access to medical care.[8] Children in farmworker families have been shown to lack health care at three times the rate of children whose parents are not farmworkers,[9] and over half have at least one unmet medical need,[10] limiting the ability of health care professionals to identify children as overweight and suggest courses of action to mitigate future excess weight gain.

The United States Department of Health and Human Services (DHHS) recommends a minimum of 60 minutes of moderate-vigorous physical activity (MVPA) for young children daily, and suggests limiting daily screen use to less than two hours.[11] The National Association for Sport and Physical Education suggests children maintain activity levels of at least one structured and one unstructured hour per day, and avoid being sedentary for more than an hour at a time except while sleeping.[12] Several studies have indicated Latino children's level of physical activity falls far below recommended levels.[13–15] For example, in Houston, Texas, a study of 483 Latino and African American children found only 23% of the sample met MVPA guidelines,[13] while a study of Latino children in Philadelphia found only 19% achieved the desired amount of PA.[14] Results from the North Carolina-based KAN-DO study found that, on average, Latino children, as well as children from other racial/ethnic groups, engaged in 14.9 minutes per day in MVPA.[15]

Using cohort data collected from a study of children in farmworker families, this article seeks to characterize different states of PA among preschool-age children in Latino farmworker families, identify factors that are predictive of membership in more or less active states, and determine if states predict age and gender-specific BMI and weight percentile after controlling for energy intake.

METHODS

Data used for this analysis come from Niños Sanos, a 2-year prospective cohort study of young Latino children living in farmworker families in North Carolina, designed to investigate the development of obesity in pre-school aged children. Inclusion criteria were: 1) mother self-identified as Latina, 2) at least one member of the family performed farm work in the past year, and 3) the mother had a child between the ages of 2.5 and 3.5 years. Mothers of children with special healthcare needs limiting PA were excluded. *A priori* power

calculations determined a sample of 250 children would be needed to detect small-to-medium differences in physical activity and dietary patterns over the two-year course of the study after accounting for expected loss to follow-up.

Sampling and Recruitment

Given the narrow age range of children, a site-based sampling plan was used to form a large contact base representative of farmworkers with young children in North Carolina.[16–19] "Sites" are places and organizations with which target members of the community are associated. Site categories included migrant and regular Head Start Programs, migrant education programs, community health centers, Special Supplemental Nutrition Program for Women, Infants and Children, non-profit organizations serving Latino immigrants, and stores, churches, and events serving primarily farmworkers. Door-to-door recruitment and recruitment of subjects from recent farmworker studies and personal networks was done. The study was designed to recruit approximately one quarter migrant farmworker families and the remainder seasonal farmworker families, who maintain the same residence year round and work seasonally in agriculture.

A trained bilingual data collector contacted potential participants. Organizations subject to privacy regulations (i.e., Head Start) used staff members to solicit permission to contact parents. Once contact was made, the data collector introduced the study and screened for inclusion criteria. Requirements and incentives of study participation were explained and eligible families were invited to participate. All participating parents provided signed informed consent. The Wake Forest School of Medicine Institutional Review Board approved the study, and a certificate of confidentiality was obtained from the National Institutes of Health to protect subject anonymity.

Precise calculations of rates of participation and refusal are unavailable given the nature of the site-based sampling. Eligibility of persons refusing to participate is unknown. Lists of potential participants provided by organizations may have been incomplete, and some eligible individuals may have avoided contact at events.

Data Collection

Data for this analysis were collected at six time points, baseline, 3, 6, 9, 12, and 24 months. Typically, baseline data were collected at the time of recruitment. All interviews were conducted in Spanish and took place in participants' homes or another preferred location between the period of 4/19/11 – 4/20/12. The interview captured information on demographic, family, and household characteristics, patterns of migration, and beliefs about children's PA. Child weight was measured using a Tanita model BSB800 digital scale capable of determining weight to the nearest 0.100 kg. Height was determined twice using a portable stadiometer without shoes. If the two measurements differed by more than 5mm, another measurement was taken and the two closest values for height were averaged.

Physical activity data were collected using Actical accelerometers (Mini Mitter Company, Inc., Bend OR.[20] Each device was attached to an elastic belt positioned above the child's iliac crest per usual protocols. At each of the six time points, an interviewer interviewed the mother and gave the mother the accelerometer and the belt. Children were asked to wear the

belt for seven days and only remove the device for swimming, bathing, and sleeping. On the eighth day, the interviewer returned to retrieve the accelerometer and belt. Mothers were compensated with $10 for completing each interview and $10 for completing each accelerometer protocol. Children were incentivized with three $1 gifts of their choice, one given to them at the interview, and two at the time of device retrieval if they did wear the accelerometer for at least five days, including a weekend day. Examples of a $1 gift included balls of safe size, coloring books, and stickers. Eighty five percent of children provided at least five days of data including a weekend day. A successful wear day was defined as including at least eight hours of wear data.

Energy intake measurement was used as a controlling variable in the study. The variable was derived from dietary data, which were collected at baseline by bilingual staff members using three 24-hour recalls during a 7-day period, including one weekend day and two weekdays using the Nutrition Data System for Research (NDS-R) software (version 11). This program was developed by the Nutrition Coordinating Center at the University of Minnesota and uses the multiple-pass method.[21] The first recall was conducted face-to-face, and subsequent interviews were conducted by telephone or in person when possible. Participants were given an incentive of $10 per completed recall. Mothers without telephone access were loaned a cell phone programmed only for study use. Mothers were given a printed serving size guide and the interviewer measured the size or volume of their child's usual bowl, plate and cup to help facilitate calculation of serving sizes. For children enrolled in preschool or daycare, food intake data were collected directly from the caregivers.

Measures

BMI percentile and weight percentile—Age and gender-specific BMI percentiles, based on CDC growth charts published in 2000[22] were used to form the dependent variable in a model of which PA status was the independent variable[23]. BMI was classified as normal (BMI ≥ 5th percentile and < 85th percentile), overweight (≥ 85th percentile but < 95th percentile), and obese (≥ 95th percentile). A BMI < 5th percentile was considered underweight. For children of this age range, height measurement may contain large measurement errors. We also used CDC-based age and gender-specific weight percentile in a secondary analysis

Physical activity—Accelerometers provided data used to determine minutes spent sedentary and engaged in MVPA per day. They were initialized with 15-second epochs, which were then used to determine intensity based on the number of accelerometer counts.[24] Intensity was defined as sedentary (fewer than 12 counts/epoch), light activity (12–714 counts/epoch), and MVPA (>714 counts/epoch). The total number of epochs in each category was divided by the number of observation days to derive average minutes sedentary, light activity, and MVPA per day.

Based on previous experience with accelerometers,[25] using only minutes of MVPA per day may not entirely capture the variation of physical activity patterns in this population. Two children could have spent the same amount of time in MVPA, but differ in amount of light and less intense PA. Also, activity could be concentrated in a single period or interspersed

throughout the day. Given these considerations, we extracted activity pattern data from accelerometer readings and created a PA profile. The nine variables used to formulate the profile included average total minutes of light activity per day, average minutes per bout of MVPA, average MET score per MVPA bout, total minutes of MVPA per day, total bouts of MVPA per day, standard deviation of total MVPA bouts per day, standard deviation of average MET score per MV bout, autocorrelation between observations, and total minutes spent sedentary per day.

Other measures—If the mother reported either parent moved from place to place to perform farm work, the family was classified as migrant; otherwise, they were classified as seasonal. Children who participated in at least ten hours of Head Start per week were considered to be participating in Head Start.

Dichotomous measures of the physical and social environments were created based on mothers' responses to queries: if traffic made walking on the streets around their home difficult, whether dogs were allowed to roam freely in their neighborhood, whether she sets limits on screen time (e.g., watching television or playing video games), if she took her child to play spaces such as parks, whether the frequency to play space was less than weekly or weekly or more, and if she was concerned regarding her child's level of activity.

Other dichotomous measures included warmer versus cooler season according to the date on the accelerometer, and whether mother was employed.

The energy intake at baseline was calculated as a mean of the total kilocalories per day from the three 24-hour recalls at each time point. Baseline energy intake was used as a controlling variable in the analysis.

Statistical Analyses

Descriptive statistics were used to summarize sample characteristics. The Hidden Markov model (HMM)[26–29] was used to identify different PA states based on the activity profile. The HMM can be viewed as a longitudinal extension of latent class analysis. At each time point, children were categorized into one of the hidden (latent) states. The number of states is typically selected using the Bayesian Information Criterion (BIC).[30] A child could change state over the course of the study period. Unlike traditional aggregation of activity, HMM considers multiple features of the accelerometer data and classifies individuals more accurately. It also provides interpretable information on the dynamic of change in children's activity levels over time. We assumed that missing values were Missing-At-Random. When accelerometer data were missing at a specific time point, a predicted value of hidden state was imputed based on the previous measures of the same participant. This strategy avoided leaving out all participants with missing visits. The HMM analysis was conducted using a specialized downloadable software program.[31]

Risk factors related to low physical activity were identified using bivariate correlation analysis. Longitudinal models were applied to each individual predictor for physical activity status after controlling for trend. The factors included social and environmental variable, as well as season and maternal employment status. Factors that were significant at the $p<.1$

level in the bivariate correlation analysis were retained and included in the overall multivariable model. PA status was subsequently used as a predictor variable for age and gender-specific BMI and weight percentiles. Although it is known that other factors such as genetic basis determine weight change,[32] in the model we included the other most salient factor in the energy balance equation, average baseline energy intake (Kcal/day), as a controlling variable. Observations with missing values in a covariate at a specific time point were not included in the analysis. Besides the specialized HMM program, the analyses were also conducted using SAS v9.4 (SAS Inc., Cary, NC). Specifically, the SAS procedure PROC MIXED was used for longitudinally assessing the effects of PA status and energy intake. Statistical tests of significance in the final multivariable analyses were all two-sided and set at the significance level of 0.05.

RESULTS

A total of 244 mother-child dyads (out of a total of 248 enrolled in the study) contributed data to this analysis. At baseline, 248 surveys were collected (100%); the average rate of survey completion across the five subsequent time points was 87% (range 76–90%). Participants missing accelerometer data because of device malfunction or refusal to wear the device were not included in the analysis (5.5% of the sample). Rates of missing values for energy (kcal), BMI, and weight-for-height were 2.5%, 1.3% and <1%, respectively.

Table 1 provides information regarding sample characteristics. About a quarter (28.7%) of mothers were younger than 25, and 56.1% fell between the ages of 26–35. Most mothers (73.7%) completed fewer than 10 years of school. The large majority (90.2%) were born outside the US, with most being born in Mexico (85.7%). Nearly all children (98.8%) were born in the US, and most (77.5%) attended Head Start. Per design, 73% of families were seasonal farmworkers and the others migrant.

On average, children were sedentary 394.9 minutes per day and engaged in only 9.34 minutes of MVPA per day. Median child BMI was at the 80.5th percentile, and median weight was at the 63th percentile; 20.9% were overweight and 23.0% were obese.

Using the nine variable PA profile, HMM identified multiple states. However, only small and clinically inconsequential differences were observed between many states, and meaningful characterization was hindered. Therefore, a two-state model featuring a less active state and a more active state was selected. In terms of light activity, small but significant differences were noted in total bouts per day, average minutes per bout, average MET score per bout, and total minutes per day (Figure 1, Table 2). Regarding MVPA, the more active state displayed more bouts (12.98 versus 4.63, $p<.001$), more minutes per bout (1.40 versus 1.32, $p<.001$), higher MET score per bout (3.89 versus 3.67, $p<.001$), and more minutes per day (18.96 versus 6.18, $p<.001$). Children in the less active state spent about 16 more minutes per day sedentary, but the difference was not significant ($p=.09$).

Approximately 75% (range 73%–76%) of participants were categorized as belonging to the lower activity state throughout the first year of the study. However, this number fell to 59% at the end of the study (24m). Children commonly changed states; only 29.3% remained in

the less active state during the entire study period, and only one child consistently remained in the more active state. According to the transition probability estimates derived from the HMM, at any time point, children initially in the less active state had a 29.1% probability of moving to the more active state, and children in the more active state had a probability of 52.8% of moving to the less active state. Due to the larger number of children in the less active state, the two states changed little in terms of size until the end of the study.

Several variables were examined as possible predictors of state membership. Children's physical environment, as measured by the presence of dogs running loose and whether street traffic makes walking unsafe, did not show a significant effect. Measures of children's social environment, which included parental limits on screen time, whether children are taken to play spaces, and whether the mother is employed, did not significantly impact state membership. Only one marginally significant variable was identified: mother's concern regarding her child's activity level ($p<.1$). From the bivariate correlation analysis, it was determined that no further overall model was required.

Our hypothesis that children in the more active state would have lower BMI and weight-for-age percentiles was not supported (Table 3). Children in the more active state had an average BMI percentile of 67.44 and weight percentile of 59.60. Children in the less active state had an average BMI percentile of 72.53 and weight percentile of 61.73; however, these differences were not statistically significant ($p=.74$). Fewer children in the more active state were overweight (16.7%) or obese (18.5%) compared to the less active state, in which 22.1% were overweight and 24.3% obese, but these differences were also not significant ($p=0.34$). For both the age-and gender-specific BMI and weight percentile outcomes, energy intake (Kcal/day) was marginally significant.

DISCUSSION

Hidden Markov Modeling was used to derive two distinct PA states (less active and more active) among preschool age participants in the Niños Sanos study. However, both groups fell far below recommended guidelines for PA in this age group. Additionally, the number of participants who belonged to the lower activity group remained fairly constant until the final measurement period at the end of year two. Only one marginally significant factor, mother's concern regarding PA, predicted membership in the more active state, and state itself did not predict BMI or weight percentiles after adjustment. Caloric intake, on the other hand, did appear to have a marginally significant impact on BMI and weight percentiles. Consistent with other studies of Latino farmworker children, more children were overweight (20.9%) or obese (23.0%) compared to the national average for children of all racial/ethnic backgrounds in this age group (14.4% overweight, 8.4% obese).[1]

In a previous cross-sectional study that examined physical activity levels of the children in Niños Sanos,[25] several characteristics were found to have significant effects on PA. For example, in multivariate analysis children who attended Head Start or lived in areas without dogs running loose were sedentary 89 and 54 minutes longer per day, respectively, than those who did not (both $p<.01$). The findings that these variables did not seem to affect membership in the more or less active PA state and that PA state did not have an effect on

weight related outcomes in the current study were actually quite revealing. We attributed these findings to the following points: (1) that Latino farmworker children were highly sedentary; (2) that there might be statistical differences in the levels of PA between the two identified states but their difference in physical activity was likely not clinically meaningful; and (3) that a large proportion of children switched between the PA states. Although no robust predictor of PA emerged, the findings of the study point to an important and worrisome fact - that there exists a high level of homogeneity in the PA of children of farmworker families, and that they all had alarmingly high level of sedentary behavior and substantially lower level of MVPA than current recommendations.[11]

Although parenting practices are important, many other factors appear to influence children's level of physical activity and deserve consideration as part of a broader strategy to improve children's health.[33] For example, although we did not find a significant relationship between environment and PA, several studies have documented such an association. Preschoolers in neighborhoods with less safe streets, in terms of high rates of pedestrian-automobile injuries, had decreased amounts of PA and greater skinfold thickness.[34] Children with greater access to parks have been reported as having smaller skinfolds[34] and lower weights.[35, 36] Parents are more likely to encourage PA when they perceive their neighborhood as generally safe,[37] and a high level of neighborhood disorder has been associated with higher BMI z-scores after adjusting for other variables.[38]

A concerted effort is needed to raise physical activity levels among all children, but the need is especially acute for Latino children of farmworker families. In-depth interviews with mothers in farmworker families have identified beliefs that may hamper efforts to encourage PA.[7] For example, mothers expressed concern that excessive PA might cause illness or injury. Sedentary behavior was valued because it could benefit learning. Other research has identified concerns about traveling away from home due to lack of immigration documents, parental time constraints, and the conditions of farmworker housing and neighborhoods.[39]

This study has several strengths and contributes to the literature regarding physical activity and sedentary patterns in a high-risk group. Physical activity was measured objectively and reliably with accelerometers. There was limited loss to follow-up and few missing data. This could be credited to the efforts for engaging the families throughout the study and intensive oversight in the data collection process. On the other hand, the study was geographically limited to farmworker families on the East Coast, and findings may not be generalizable to other regions. The study also has not directly included developmental considerations. For example children's nap times may decrease during the 2 years of the observation period. This may underlie the lower prevalence of the low PA state at the last time point.

Additional research is needed to better understand how diet and PA interact to influence weight in high-risk groups such as children of Latino farmworkers. Any intervention to lower rates of obesity should be grounded in a theoretical understanding of these factors. The need to better understand these relationships should not, however, slow the realization of programs and policies intended to help children achieve healthy weights. As research continues to accumulate, meaningful interventions to curb the childhood obesity epidemic must continue to be developed, implemented, and refined. Given that these children may be

even less active than previously thought, the need for change is urgent. Slowing and ultimately reversing the obesity epidemic is an essential public health goal.

Acknowledgments

Acknowledgements/Funding Source

The work was supported by the US NIH grants R01 HD059855 and R01 HL101066-01.

List of Abbreviations

BMI	body mass index
DHHS	Department of Health and Human Services
HMM	hidden Markov modeling
MET	metabolic equivalent of task
MV	moderate-vigorous
PA	physical activity

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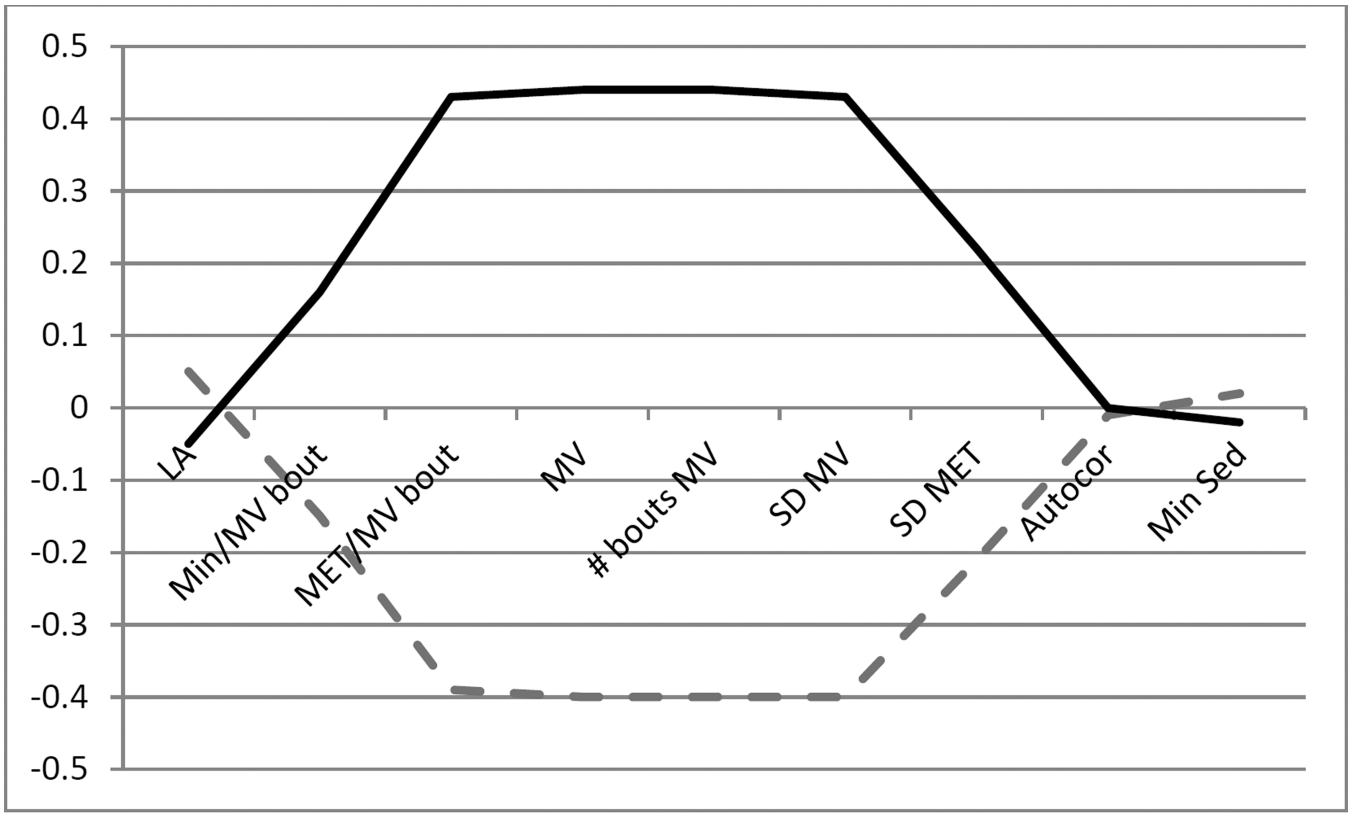

Figure 1.

PA profile and the less active and more active states. Solid (dashed) line shows the profile of more (less) active state. The vertical scale is in standardized unit of z-score.

LA= Total minutes of light activity per day

Min/MV bout= Average minutes per bout of MV activity

MET/MV bout= Average MET score per MV bout

MV = Total minutes of MV activity per day

bouts MV = Total number of bouts of MV activity per day

SD MV = Standard deviation of total MV number of bouts per day

SD MET = Standard deviation of MET score per MV bout

Autocor = Autocorrelation between two consecutive observations in count

Min Sed = Total minutes of sedentary activity per day

Table 1

Selected Characteristics of Mother-Child Dyads in Latino Farmworker Families, Baseline (N=244)

Characteristic	N (%)
Mother's age (yr)	
18–25	70 (28.7%)
26–35	137 (56.1%)
36–45	37 (15.2%)
Mother's education (yr)	
0–6	106 (43.4%)
7–9	74 (30.3%)
10+	64 (26.2%)
Mother's place of birth (yr)	
US	11 (4.50%)
Mexico	209 (85.7%)
Other	24 (9.80%)
Child's age (yr)	
2	128 (52.5%)
3	116 (47.5%)
Child's gender	
Male	118 (48.4%)
Female	126 (51.6%)
Child's place of birth (yr)	
US	241 (98.8%)
Other	3 (1.20%)
Attends Head Start	
No	186 (77.5%)
Yes	54 (22.5%)
Family Status	
Migrant	66 (27.0%)
Seasonal	178 (73.0%)
Dogs run loose in neighborhood	
No	111 (47.6%)
Yes	122 (52.4%)
Street traffic impedes walking	
No	162 (68.1%)
Yes	76 (31.9%)
Parents set limits on screen time	
No	181 (77.7%)
Yes	52 (22.3%)
Child taken to play spaces	
No	169 (69.5%)
Yes	74 (30.5%)

Characteristic	N (%)
Parent is concerned regarding child's level of activity	
No	217 (89.3%)
Yes	26 (10.7%)
Child’s BMI Category	
Normal	132 (56.2%)
Overweight	49 (20.9%)
Obese	54 (23.0%)

Table 2

Differences in Baseline Physical Activity Parameters, Less Active and More Active States

	Less active state		More active state		
	Mean	**SD**	**Mean**	**SD**	**P value**
Light Activity					
Total bouts per day	75.76	14.20	79.48	16.62	<0.01
Average minutes per bout	5.60	1.47	5.16	1.51	<0.001
Average MET score per bout	1.99	0.12	2.15	0.14	<0.001
Total minutes per day	405.15	69.99	397.27	81.67	0.01
Moderate/ Vigorous Activity					
Total bouts per day	4.63	2.46	12.98	4.91	<0.001
Average minutes per bout	1.32	0.55	1.40	0.17	<0.001
Average MET score per bout	3.67	0.14	3.89	0.20	<0.001
Total minutes per day	6.18	3.72	18.96	7.79	<0.001
Other Parameters					
Minutes per day sedentary	398.81	143.85	382.96	126.18	0.09
BMI for age percentile	72.53	27.71	67.44	29.37	0.74
Weight for age percentile	61.37	29.85	59.60	28.48	0.75

Table 3

Longitudinal Analysis of BMI Percentile and Weight Percentile Over 2 Years with Physical Activity State as Primary Predictor

Effect	Estimate	Standard error	P-value
BMI percentile (age- and gender-specific)			
State *	0.56	1.70	0.74
Time	0.13	0.20	0.51
Energy intake (Kcal/day)	0.004	0.0025	0.11
Weight percentile (age- and gender-specific)			
State *	−0.39	1.24	0.76
Time	0.23	0.14	0.10
Energy intake (Kcal/day)	0.003	0.0018	0.07

* Reference category = Active State