Preventive Medicine Reports 18 (2020) 101068

Contents lists available at ScienceDirect

Preventive Medicine Reports

journal homepage: www.elsevier.com/locate/pmedr

Short communication

Identifying patterns of physical activity and screen time parenting practices and associations with preschool children's physical activity and adiposity

Cody D. Neshteruk[a], Stephanie Mazzucca[b], Amber E. Vaughn[c], Deborah J. Jones[d], Dianne S. Ward[c,e,*]

[a] Department of Population Health Sciences, Duke University, Durham, NC, United States
[b] Prevention Research Center in St. Louis, Washington University in St. Louis, St. Louis, MO, United States
[c] Center for Health Promotion and Disease Prevention, University of North Carolina at Chapel Hill, Chapel Hill, NC, United States
[d] Department of Psychology and Neuroscience, University of North Carolina at Chapel Hill, Chapel Hill, NC, United States
[e] Department of Nutrition, University of North Carolina at Chapel Hill, Chapel Hill, NC, United States

ARTICLE INFO

Keywords:
Parenting
Physical activity practices
Screen media practices
Sedentary behavior
Physical activity
Adiposity
Preschool children

ABSTRACT

Although physical activity and screen time parenting practices influence children's behaviors, little work has examined how these practices work in combination. The purpose of this study was to identify patterns of physical activity and screen time parenting practices, and examine differences in preschool children's physical activity, sedentary behavior, and adiposity among the identified patterns. Data were collected in 2009–2012 from 319 parent–child dyads enrolled in a randomized trial testing a parent-focused obesity prevention intervention. At baseline, physical activity and screen time parenting practices were assessed using a validated self-report survey. Children's physical activity and sedentary behavior were measured using accelerometers and child anthropometrics were objectively measured. Latent profile analyses identified patterns of physical activity and screen time parenting practices. Differences in child outcomes were tested among the identified classes. Three parent classes were identified: Rewarders (n = 165), Activity Supportive (n = 98), and Screen Time Permissive (n = 56). Rewarder parents were characterized by the highest scores on using physical activity and screen time to reward or control children's behavior. Activity Supportive parents generally had the highest scores on practices to promote physical activity, while Screen Time Permissive parents had the highest scores on practices facilitating screen time. There were no differences in the mean child physical activity, sedentary behavior or BMI z-score among the three classes. Findings revealed distinct classes of parents that could provide modifiable targets for family-based physical activity promotion, but more work is needed examining the influence of these patterns longitudinally and in different populations.

1. Introduction

Increased physical activity and limited sedentary behavior have been linked to children's healthy growth and development, including reduced adiposity and improved cardio-metabolic fitness, motor development, academic performance, and social and emotional health (Timmons et al., 2012; Biddle and Asare, 2011; Donnelly et al., 2016; Pate et al., 2013). However, many young children do not obtain sufficient physical activity and engage in excessive amounts of sedentary behavior, particularly in the form of screen time. Findings from a global review of children's objectively measured physical activity and sedentary behavior showed that preschool aged children spend only about 47 min/day engaged in moderate to vigorous physical activity (MVPA), while spending 10 h/day engaged in sedentary behavior (Hnatiuk et al., 2014). Furthermore, many young children greatly exceed screen time recommendations (Tandon et al., 2011; Loprinzi and Davis, 2016). Effective strategies are needed to promote young children's physical activity, while reducing sedentary behavior and screen time.

Parents play an important role in shaping children's physical activity, sedentary behavior, and screen time, in particular through their physical activity and screen time parenting practices, which are behaviors that serve to promote or reduce aspects of children's physical activity or screen time and subsequent sedentary behavior (Vaughn et al., 2013). These practices have been shown to be influential in promoting children's physical activity and reducing screen time (Beets et al., 2010; Trost and Loprinzi, 2011; Verloigne et al., 2012; Xu et al.,

* Corresponding author at: Center for Health Promotion and Disease Prevention, 1700 Martin Luther King Jr. Blvd., Chapel Hill NC, 27514, United States.
E-mail address: dsward@email.unc.edu (D.S. Ward).

https://doi.org/10.1016/j.pmedr.2020.101068
Received 13 August 2019; Received in revised form 10 February 2020; Accepted 17 February 2020
Available online 20 February 2020

Table 1
Physical activity and screen time practice indicator variables.

Practice (items)	Sample Item	Possible Range	Cronbach's α	Mean ± SD
Physical activity practices				
Rules around activity play indoors (14)	When my child is inside the house his/her play should be calm and quiet.	1.0–3.54	0.86	1.39 ± 0.28
Rules around active play outdoors (4)	How often do you ask your child not to run when (s)he is playing outside?	1.0–6.0	0.69	2.14 ± 0.84
Use of PA to reward/control behavior (5)	How often do you offer sports or physical activities to your child as a reward for good behavior?	1.0–6.0	0.80	3.08 ± 1.0
Limiting outdoor play because of weather (2)	How often do you let your child play outside on hot days? On cold days? (reverse coded)	1.0–6.0	0.85	2.73 ± 1.04
Explicit modeling and enjoyment of PA (10)	During a typical week, how often does your child see you doing, or going to do, something that is physically active?	1.0–5.2	0.88	3.43 ± 0.74
Verbal encouragement of PA (7)	During a typical week, how often do you say things to encourage your child to do physical activities or play sports?	1.0–6.0	0.77	3.82 ± 0.85
Logistic support for sports (3)	How active are you in enrolling your child in sports?	0.67–4.33	0.69	2.40 ± 0.91
Logistic support for active play (4)	During a typical week, how often do you take your child to the park to play?	0.75–6.75	0.65	4.66 ± 1.16
Importance and value of PA (3)	How important is it for your child to be physically active when (s)he grows up?	1.0–5.0	0.70	4.48 ± 0.53
Screen time practices				
Limiting or monitoring ST (10)	I am in charge of how much TV my child watches during his/her free time at home.	0.5–6.0	0.79	3.51 ± 1.19
Use of ST to reward/control behavior (4)	How often do you take away TV, video, or movie time a punishment for bad behavior?	1.0–6.0	0.79	3.07 ± 1.04
Exposure to TV (3)	How many days per week does your family have the TV on during breakfast/evening meal?	0.33–6.67	0.66	2.61 ± 1.64
Explicit modeling and enjoyment of ST (6)	I enjoy watching TV/movies with my child.	1.0–5.5	0.76	3.75 ± 0.71

Abbreviations: screen time (ST), physical activity (PA), television (TV).

2015; Edwardson and Gorely, 2010). For instance, parents' explicit modeling, facilitation of activity through logistic support (e.g., providing transportation or equipment), and co-participation in activity have been associated with increased child physical activity (Lloyd et al., 2015; Davison et al., 2003; Edwardson and Gorely, 2010), while setting limits around screen time has been associated with reduced screen time (Tang et al., 2018). Leveraging these parenting practices may be an effective way to promote children's physical activity and reduce excess screen time and sedentary behavior.

Research on physical activity and screen time parenting practices has mostly focused on the impact of individual practices on child behavior, but parents typically employ a variety of practices (Masse et al., 2016). To date, few studies have tested how physical activity and screen time parenting practices work in conjunction. Identifying combined patterns of physical activity and screen time parenting practices may elucidate how these practices work together, while also providing a broader understanding of how parents influence their children's physical activity, screen time, and sedentary behavior. Therefore, the aims of this study were to 1) identify patterns of physical activity and screen time parenting practices and 2) examine if there were differences in children's physical activity, sedentary behavior, and adiposity by identified physical activity and screen time parenting practice patterns.

2. Methods

This study used baseline data from the Parenting SOS trial, a randomized controlled trial testing the efficacy of a 35-week parent-focused childhood obesity prevention intervention (Clinical Trials ID: NCT00998348) (Ward et al., 2011). All protocols were approved by the University of North Carolina at Chapel Hill Institutional Review Board.

2.1. Participants

Participants included a convenience sample of 319 parent–child dyads from central North Carolina. Participant recruitment has been described elsewhere (Ward et al., 2011). To be eligible, families had to have at least one child between the ages of 2 to 5 years, at least one parent with a self-reported body mass index (BMI) greater than 25, willingness to complete intervention activities, and the ability to speak and read English.

2.2. Data collection and measures

Data were collected from 2009 to 2012. Informed consent was obtained from all participants prior to data collection. In-person data collection occurred at community locations convenient to families. Upon arrival, parents and children completed anthropometric measures and were fitted with accelerometers. Children then participated in child activities while parents completed study questionnaires.

2.2.1. Demographics

Parents completed a self-report demographic questionnaire at baseline that captured parent age, sex, race/ethnicity, marital status, education, employment status, annual family income, and number of children in the home. Parents also self-reported their child's sex and date of birth.

2.2.2. Physical activity and screen time parenting practices

Parents self-reported their physical activity and screen time parenting practices using a questionnaire developed for Parenting SOS. Previous exploratory factor analyses using these data identified physical activity and screen time parenting practice subscales that demonstrated acceptable validity and reliability (Vaughn et al., 2013). Nine physical activity parenting practices and four screen time parenting practices were used in this study. Items assessed parent practices using primarily Likert responses (e.g., "*never*" to "*very often*"; "*strongly*

Table 2
Parent demographic characteristics (n = 319).

Characteristics[a]	Parents, n (%)
Age, mean ± SD	35.4 ± 6.0
Body mass index, mean ± SD	30.1 ± 7.1
Parent	
Mother	292 (92)
Father	22 (7)
Grandmother	3 (1)
Race	
Black or African American	126 (40)
White or Caucasian	164 (52)
Other	26 (8)
Hispanic/Latino, (yes)	19 (6)
Marital status	
Married or living with partner	245 (77)
Single or never married	52 (16)
Divorced or separated	21 (7)
Widowed	1 (0.3)
Education	
High school graduate or GED	13 (4)
Some college or technical school	64 (20)
College graduate	137 (43)
Masters/Doctoral degree	104 (33)
Annual family income ($USD)	
< $25 K	42 (13)
$25 K to $49,999	72 (23)
$50 K +	198 (63)
Employment status	
Part time	27 (9)
Full time	195 (64)
Work at home	19 (6)
Stay at home parent	36 (12)
Unemployed	8 (3)
Student	14 (5)
Other	6 (2)
Children in the home, mean ± SD	1.9 ± 0.9
Activity minutes/10 h, mean ± SD	
Sedentary behavior	412.6 ± 39.0
Light activity	161.6 ± 33.7
Moderate to vigorous activity	22.2 ± 12.2

Abbreviation: general education diploma (GED).
Missing values: age (n = 1), parent (n = 2), Hispanic/Latino (n = 1), race (n = 3), education (n = 1), income (n = 7), employment (n = 14); activity (n = 19).

disagree" to "*strongly agree*") and occasional open-ended questions (e.g., *"During the last month, how many times have you taken your child to play at a park?"*). Six open-ended items were converted into categorical responses and 13 items were reverse coded, so that higher scores indicate more frequent use of the practice. To calculate subscale scores, all items in the subscale are averaged. Information on each subscale including number of items, sample items, possible range of scores, and internal consistency are shown in Table 1. A full list of items and a description of the scoring for each subscale is available upon request.

2.2.3. Parent and child physical activity and sedentary behavior

Parent and child physical activity and sedentary behavior were assessed using ActiGraph GT3X accelerometers (ActiGraph, Pensacola, FL). Monitors were worn over the participant's right hip for seven consecutive days, during waking hours only. For parents, data were captured in 60-second epochs, while child data were captured in 15-second epochs to account for short bursts of activity. Data were processed using the National Health and Nutrition Examination Survey (NHANES) SAS code (Troiano et al., 2008). Non-wear time was identified by isolating periods of at least 60 min with zero counts (Choi et al., 2011). Wear criteria (four days with at least six hours of wear) and age appropriate cut points (i.e., Troiano for adults, Evenson for children) were applied to calculate minutes of sedentary, light, and MVPA. (Troiano et al., 2008; Evenson et al., 2008) To account for differences in wear time, estimates were standardized to a 10-hour day. Valid physical activity data were available for 282 children.

2.2.4. Parent and child anthropometrics

Parent and child standing height was measured to the nearest 1/8 inch using Shorr or Seca infant/child/adult stadiometers (Shorr Productions, Olney, MD; Seca Corporation, Columbia, MD) and weight to the nearest 0.1 pound with a Seca model 770 portable electronic scale (Seca Corporation, Columbia, MD). Trained data collectors took all measures at least twice while participants were in light clothing without shoes. Height and weight were used to calculate parent BMI and child BMI z-score was calculated using the Centers for Disease Control (CDC) SAS code (Ogden et al., 2002).

2.3. Statistical analysis

Latent profile analysis (LPA) in Mplus7 was used to identify patterns of physical activity and screen time parenting practices. (Muthén, 2019) LPA is used to identify underlying homogenous groups (i.e., classes) based on continuous indicator variables (Collins and Lanza, 2010). Indicator variables for these analyses include the physical activity and screen time parenting practices shown in Table 1. In LPA, it is not required that indicator variables are standardized (Hagenaars and McCutcheon, 2002). Five different latent profile models were estimated, with each model increasing in class size from two to six classes. To identify the best fitting model, we used a combination of model fit statistics and interpretability including 1) Lo-Mendell-Rubin adjusted Likelihood Ratio Test (LMR LRT), 2) Bayesian Information Criterion (BIC), 3) Bootstrap Likelihood Ratio Test (BLRT), 4) number of individuals assigned to each class and 5) interpretability of the classes based on existing literature. Because there was no variation in the indicator variable "rules around active play indoors," a second set of models were constructed excluding this variable, yielding a final set of models based on eight physical activity and four screen time parenting practices. Following the identification of the best fitting model, individuals were assigned to the class with the highest probability of membership.

Remaining analyses were conducted using SAS 9.4. To describe demographic characteristics of the total sample and each identified class, means and standard deviations were calculated for continuous variables and frequencies and percentages were reported for categorical variables. To determine if classes differed by demographic characteristics, analysis of variance (ANOVA) was used for continuous variables and chi square tests or Fisher's exact tests were used for categorical variables. Group differences in children's minutes of physical activity, sedentary behavior, and BMI z-score were first examined by parent class membership using a series of bivariate linear regression models. Models included parent class membership as a categorical predictor of each child outcome. A contrast statement was used to compare groups (e.g., class 1 to class 2). Next, multivariate linear regression models were constructed by adding demographic covariates including child sex and age, parent BMI, parent race, education, and employment status, and annual family income to the models.

3. Results

Characteristics of the parents included in the LPA are shown in Table 2. On average parents were 35.4 ± 6.0 years old and had a BMI of 30.1 ± 7.1. Most (92%) parent respondents were mothers. The majority of parents identified as White (52%) or Black (40%), married/living with a partner (77%), having at least a college degree (76%), working full time (64%), and having an annual family income over $50,000 (63%). Families had on average two children in the home. Half (51%) of children were male and the mean age of children was

Table 3
Fit indices of 2–6 class model solutions.

# classes	LMR LRT [a]	Entropy	BIC	BLRT [a]
2	0.0497	0.709	9881.014	0.0000
3	0.4702	0.728	9841.035	0.0000
4	0.7337	0.758	9821.052	0.0000
5	0.7191	0.770	9820.867	0.0000
6	0.2424	0.805	9840.475	0.0000

(a) p values; a p value < 0.05 indicates the current class solution is better than k-1 classes.

3.5 ± 0.8 years.

3.1. Latent profiles

Model fit statistics for the 2–6 class solutions are shown in Table 3. The LMR LRT indicated that the 2-class model was the best fitting model, while the BIC indicated either the 3-class or 4-class model. There was only a small decrease in the BIC between the 3-class and 4-class models (i.e., 9841 vs 9821) and both produced classes with at least 10% of the sample assigned to each class. Additionally, the 3- and 4-class models provided more meaningful patterns compared to the 2-class model based on the parenting literature. A comparison of the 3- and 4-class models showed that there were three distinctive patterns of use of physical activity and screen time parenting practices; however in the 4-class model these patterns were less clearly defined with the addition of the fourth class. Because the 3-class model provided a clearer interpretation of the patterns, this model was chosen as the best fitting model.

Estimated means for the eight physical activity and four screen time parenting practice indicator variables included in the final model are shown in Table 4 for each of the identified classes. The largest class, *Rewarders* ($n = 165$; 52%), was characterized by parents who exhibited the highest scores for using physical activity and screen time as a reward or to control children's behavior. *Rewarder* parent scores for the other practices generally fell in between the scores of the remaining two classes. *Activity Supportive* parents ($n = 98$; 31%) made up the second largest group. This group was characterized by parents with the highest scores on practices supportive of physical activity (e.g., providing logistic support, modeling active behavior, limiting or monitoring screen time) and lowest scores on practices that may promote screen time and sedentary behavior (e.g., rules or limits on physical activity, modeling/enjoyment of screen time). The third and smallest class, *Screen Time Permissive* ($n = 56$; 18%), was characterized by parents with the lowest scores on limiting or monitoring screen time and highest scores on practices that promote screen time (e.g., exposure to TV, modeling/enjoyment of screen time). In general, *Screen Time Permissive* parents scored lowest on practices supportive of physical activity.

Parent demographic characteristics for each class are shown in Table 5. Statistically significant differences ($p < 0.05$) in parent BMI, parent sex, race, marital status, education, annual family income, employment status, and physical activity were found among the three identified classes. Compared to *Rewarder* and *Screen Time Permissive* parents, *Activity Supportive* parents had the lowest BMI, were more frequently fathers, and tended to be White, married or living with a partner, well educated, and higher income. Fewer *Activity Supportive* parents worked full time, but there was a greater percentage of parents who worked at home or who were stay at home parents. *Rewarder* and *Screen Time Permissive* parents tended to have similar demographic characteristics, with the exception of annual household income, where more *Rewarder* parents were considered high income. *Rewarder* and *Activity Supportive* parents had similar amounts of sedentary behavior and physical activity, while *Screen Time Permissive* parents were more sedentary and less physically active.

3.2. Association with child outcomes

Child outcomes are summarized in Table 6. There were no significant differences in children's MVPA or sedentary behavior among the parent classes. Children of *Rewarder* parents spent the most time engaged in MVPA over the 10-hour period, while spending the least amount of time in sedentary behavior. Children of *Activity Supportive* parents spent the second most time engaged in MVPA and second least in sedentary behavior. Children of *Screen Time Permissive* parents engaged in the least amount of MVPA and most sedentary behavior. There were no significant difference in child BMI z-scores among the parent classes, although the difference between the BMI z-score of children of *Rewarder* and *Activity Supportive* parents approached significance ($p = 0.05$); however, this association was attenuated after controlling for parent and family demographic characteristics.

4. Discussion

Although individual physical activity and screen time parenting practices have been shown to influence children's behaviors, relatively little is known about how parents use these practices in combination. This study used LPA to understand patterns of physical activity and screen time parenting practices, identifying three distinct classes of parents: *Rewarders*, *Activity Supportive*, and *Screen Time Permissive*. *Rewarder* parents were characterized by the highest scores for using physical activity and screen time to reward or control children's behavior. *Activity Supportive* parents generally had higher scores on practices that could be used to promote physical activity, while *Screen*

Table 4
Estimated means (SE) for parenting practices by class.

	Rewarder	Activity Supportive	Screen Time Permissive
Physical activity practices			
Rules around active play outdoors	2.28 (0.1)	1.81 (0.1)	2.32 (0.2)
Limiting outdoor play because of weather	2.81 (0.1)	2.29 (0.2)	3.30 (0.2)
Use of PA to reward/control behavior	3.39 (0.2)	2.85 (0.3)	2.61 (0.3)
Importance and value of PA	4.52 (0.1)	4.55 (0.1)	4.23 (0.2)
Logistic support for active play	4.66 (0.2)	5.45 (0.3)	3.34 (0.3)
Logistic support for sports	2.46 (0.1)	2.63 (0.2)	1.83 (0.3)
Explicit modeling or enjoyment of PA	3.45 (0.2)	3.90 (0.2)	2.62 (0.2)
Verbal encouragement for PA	4.04 (0.2)	3.92 (0.2)	3.06 (0.3)
Screen time practices			
Use of ST to reward/control behavior	3.44 (0.2)	2.44 (0.4)	3.09 (0.2)
Explicit modeling or enjoyment of ST	3.94 (0.2)	3.16 (0.2)	4.21 (0.2)
Exposure to TV	2.97 (0.6)	1.53 (0.2)	3.44 (0.7)
Limiting or monitoring ST	3.23 (0.3)	4.53 (0.2)	2.47 (1.0)

Abbreviations: physical activity (PA), screen time (ST), television (TV).

Table 5
Parent demographic characteristics by class.

Characteristics	Classes, n (%)			
	Rewarder (n = 165) [a]	Activity Supportive (n = 98) [b]	Screen Time Permissive (n = 56) [c]	P value for difference
Age, mean ± SD	35.3 ± 6.5	35.8 ± 5.4	34.8 ± 5.7	0.62 [d]
Body mass index, mean ± SD	31.1 ± 7.0	27.4 ± 6.0	32.0 ± 7.9	< 0.0001 [d]
Parent				< 0.01 [e]
Mother	155 (95)	83 (85)	54 (96)	
Father	5 (3)	15 (15)	2 (4)	
Grandmother	3 (2)		–	
Race				< 0.0001[f]
Black or African American	80 (49)	16 (17)	30 (53)	
White or Caucasian	73 (45)	68 (71)	23 (41)	
Other	11 (7)	11 (12)	3 (6)	
Hispanic/Latino, (yes)	8 (5)	7 (7)	4 (7)	0.59 [e]
Marital status				< 0.001 [e]
Married or living with partner	116 (70)	90 (92)	39 (70)	
Single or never married	33 (20)	5 (5)	14 (25)	
Divorced or separated	15 (9)	3 (3)	3 (5)	
Widowed	1 (1)	–	–	
Education				0.04 [e]
High school graduate or GED	9 (5)	1 (1)	3 (5)	
Some college or technical school	42 (25)	11 (11)	11 (20)	
College graduate	67 (41)	47 (48)	23 (41)	
Masters/Doctoral degree	47 (29)	38 (39)	19 (34)	
Annual family income ($USD)				0.03[f]
< $25 K	28 (17)	5 (5)	9 (16)	
$25 K to $49,999	34 (21)	21 (22)	17 (31)	
$50 K +	101 (62)	68 (72)	29 (52)	
Employment status				
Part time	17 (11)	7 (7)	3 (6)	< 0.0001 [e]
Full time	107 (68)	50 (53)	38 (70)	
Work at home	8 (5)	9 (10)	2 (4)	
Stay at home parent	12 (8)	19 (20)	5 (9)	
Unemployed	3 (2)	1 (1)	4 (7)	
Student	6 (4)	7 (7)	1 (2)	
Other	4 (2)	1 (1)	1 (2)	
Children in the home, mean ± SD	2.0 ± 1.0	1.9 ± 0.8	1.8 ± 0.9	0.31 [d]
Parent activity minutes/10 h, mean ± SD				
Sedentary behavior	409.6 ± 37.4	407.5 ± 42.0	429.7 ± 33.9	< 0.01 [d]
Light activity	164.5 ± 32.9	164.2 ± 35.9	149.0 ± 30.1	0.01 [d]
Moderate to vigorous activity	22.6 ± 12.4	24.2 ± 13.2	18.0 ± 8.5	0.01 [d]

Abbreviation: standard deviation (SD); general education diploma (GED); United States dollars ($USD).
(a) Missing values: parent (n = 2), race (n = 1), income (n = 2), employment (n = 8), activity (n = 12).
(b) Missing values: age (n = 1), Hispanic/Latino (n = 1), race (n = 2), education (n = 1), income (n = 4), employment (n = 4), activity (n = 6).
(c) Missing values: income (n = 1), employment (n = 2), activity (n = 2).
(d) Difference tested using analysis of variance.
(e) Difference tested using Fishers exact test.
(f) Difference tested using chi square.

Time Permissive parents had higher scores on practices promoting screen time. There were no statistically significant differences in the mean child MVPA, sedentary behavior or BMI z-score among the three parent classes.

The *Rewarder* class had the largest membership, accounting for 50% of parents. The defining characteristic of this class was the highest scores for using both physical activity and screen time as a reward or to control children's behavior, suggesting that incentivizing children's behavior may be a general strategy often employed by parents. This is consistent with standard approaches to child behavior management and evidence-based treatment approaches recommended by child clinical psychologists for this age range (Kaehler et al., 2016). For instance, parents may use the offer of screen time to prompt a desired behavior or conversely, remove screen time to discourage an unwanted behavior. Previous studies have shown that using physical activity or screen time as a reward is associated with higher physical activity and screen time

Table 6
Mean child outcomes by class.

Outcomes	Classes, mean ± SD		
	Rewarder (n = 165) [a]	Activity Supportive (n = 98) [a]	Screen Time Permissive (n = 56) [a,b]
MVPA/10 h	60.1 ± 19.9	59.0 ± 18.3	58.1 ± 22.6
Sedentary behavior/10 h	320.7 ± 35.3	323.7 ± 29.1	327.8 ± 37.3
BMI z-score	0.42 ± 1.0	0.17 ± 1.0	0.40 ± 1.0

Abbreviations: standard deviation (SD), moderate to vigorous physical activity (MVPA), body mass index (BMI).
(a) Sample size for valid physical activity and sedentary behavior data: *Rewarder* (n = 148); *Activity Supportive* (n = 83); *Screen Time Permissive* (n = 51).
(b) Missing BMI z-score (n = 1).

in children, respectively (Tang et al., 2018; Baranowski et al., 2014). Furthermore, earlier analyses of these data looking at individual parenting practices association with child physical activity and screen time showed similar relationships (Vaughn et al., 2013). If parents are going to use rewards with their children, important considerations include the type of behavior parents use as a reward (e.g., healthy vs. unhealthy) and if parents make children aware in advance of this contingency, as well as if parents use it judiciously (e.g., 10-minutes versus 1 h) and consistently.

Activity Supportive parents made up the second largest class, exhibiting highest scores for practices that would promote physical activity and limit sedentary opportunities. This shows that these parents support children's physical activity in a variety of different ways. Findings from a systematic review and meta-analysis examining the effect of physical activity parenting on children's physical activity showed that overall parent support of children's physical activity (i.e., a combination of practices) had a larger effect compared to individual practices on children's physical activity (Yao and Rhodes, 2015). Based on this previous work, the *Activity Supportive* pattern was expected to be associated with greater MPVA and decreased sedentary time. However, results indicated no significant differences in child MVPA or sedentary time among the parent classes. Earlier analyses of these data found that only logistic support for active play was associated with child MVPA (Vaughn et al., 2013). The limited associations between individual physical activity parenting practices in this previous study may explain the lack of observed differences in children's physical activity and sedentary behavior based on the overall parent pattern.

The smallest class was the *Screen Time Permissive* class, defined by parents with high scores on practices that promote screen time. Earlier analyses of these data showed that these parenting practices were associated with increased screen time (Vaughn et al., 2013). Furthermore, these parents had the highest scores on setting rules and limits around physical activity, suggesting that permissiveness may be limited to screen time parenting practices. Relative to the other groups, children of *Screen Time Permissive* parents had the most sedentary time and the least MVPA; however, differences were not significant. This suggests that *Screen Time Permissive* parents could benefit from a targeted intervention teaching other parenting strategies that promote greater engagement with and monitoring of young children.

Demographic differences were evident among the identified classes. While *Rewarder* and *Screen Time Permissive* parents shared many similarities in their demographic characteristics, *Activity Supportive* parents were markedly different, particularly in regard to socioeconomic status. For instance, 94% of these parents had at least a college degree compared to 70% and 75% in the other two classes. Studies have shown that parent education moderates the types of physical activity practices parents use, such that more educated parents use more supportive parenting practices (Gubbels et al., 2011; Chen et al., 2013; Suen et al., 2019). This may be one explanation why parents in this group had the highest scores on supportive physical activity parenting practices. Additionally, these parents were more affluent and may be able to devote more time and resources to their children's physical activity. We also observed differences in parent race among the groups, which is consistent with previous literature showing that parents from different racial and ethnic groups use different physical activity parenting practices (Davison et al., 2011; O'Connor et al., 2013). These findings suggest that parent demographic characteristics are important considerations when attempting to understand the influence of parenting practices on child behaviors.

Despite finding no differences in child outcomes among the parent classes, this study provides a foundation for future research to better understand the effect of physical activity and screen time parenting practices on children's behaviors. Future studies can build on these methods to identify patterns of parenting practices in other populations and examine their potential influence on child behaviors. Additionally, it will be important to explore how patterns influence intermediary outcomes such as child enjoy of physical activity or the parent child relationship. For instance, a physical activity intervention targeting fathers and daughters showed an improvement in the father-daughter relationship as well as physical activity (Young et al., 2019). Finally, it will be important to examine how these parenting practice patterns change over time and the predictive value of these patterns on children's later behaviors. It may be that differences in child behaviors may be more pronounced later in childhood when children's physical activity declines and sedentary behavior and adiposity increase. For example, the *Activity Supportive* pattern may mitigate declines in children's physical activity over time compared to the other parenting patterns.

5. Strengths and limitations

Although this study had a number of strengths including measurement of an array of parenting practices, objectively measured physical activity and sedentary behavior, and the use of LPA, there were several limitations. First, there may be additional indicator variables that would help distinguish class membership, as indicated by the entropy value. Additionally, we did not use the 2-class model specified by the LMR-LRT, but rather relied on the BIC and interpretability as the defining factors for model selection. This is supported by simulation studies that have shown the entropy value to be a poor indicator of model fit and the BIC to be one of the best indicators of model fit, often performing better than LMR-LRT at distinguishing the correct number of classes (Nylund et al., 2007; Tein et al., 2013). Additionally, the sample was predominantly mothers, limiting the generalizability to all parents. In the limited research with fathers, (Morgan et al., 2017; Neshteruk et al., 2009; Davison et al., 2016) there is evidence that mothers and fathers parent differently around physical activity, (Zahra et al., 2015) so future work should seek to identify patterns of fathers' physical activity practices. Finally, the sample was comprised of primarily well-educated and affluent families. It could be that parents with lower income may not have the time and resources to support children's activity compared to parents in this sample. For instance, children in this study exceeded national guidelines for preschool aged children, with an average of 273.9 min of total of physical activity per day at any intensity (i.e., light, moderate, vigorous), of which 59.3 min were MVPA (Piercy et al., 2018). This indicates a need to understand how patterns of physical activity and screen time parenting practices may impact child behaviors in higher risk populations where children are less likely to be meeting recommendations.

6. Conclusion

This was the first study to identify different patterns of physical activity and screen time parenting practices using LPA. Although there were no differences in child outcomes by the identified classes in this rather homogeneous sample, these findings can inform family-based physical activity promotion and additional efforts to understand physical activity and screen time parenting practices. Future work should seek to comprehensively assess physical activity and screen time parenting practices and continue to explore how these patterns influence children's behavior over time in different populations.

CRediT authorship contribution statement

Cody D. Neshteruk: Conceptualization, Formal analysis, Writing - original draft. **Stephanie Mazzucca:** Conceptualization, Formal analysis, Writing - review & editing. **Amber E. Vaughn:** Conceptualization, Methodology, Investigation, Data curation, Writing - review & editing, Project administration, Funding acquisition. **Deborah J. Jones:** Conceptualization, Methodology, Investigation, Writing - review & editing, Funding acquisition. **Dianne S. Ward:** Conceptualization, Investigation, Writing - review & editing, Project administration,

Funding acquisition.

Acknowledgments

We would like to thank Alice Ammerman, Asheley Skinner and Deborah Tate for their feedback on this manuscript as well as the families who participated in this study.

Conflicts of interest

None.

Funding

This work was supported by the National Heart, Lung, and Blood Institute (R01 1HL091093). Additionally, this study was conducted with support from the Nutrition Obesity Research Center at the University of North Carolina (UNC) at Chapel Hill (NIH DK056350) and the study was conducted at the UNC Center for Health Promotion and Disease Prevention, a member of the Prevention Research Centers Program of the CDC (#U48-DP000059). The sponsors had no role in the study design; collection, analysis, or interpretation of the data; writing of the article; or decision to publish this article.

References

Baranowski, T., O'Connor, T., Johnston, C., et al., 2014. School year versus summer differences in child weight gain: a narrative review. Child Obes. 10 (1), 18–24. https://doi.org/10.1089/chi.2013.0116.

Beets, M.W., Cardinal, B.J., Alderman, B.L., 2010. Parental social support and the physical activity-related behaviors of youth: a review. Heal Educ. Behav. 37 (5), 621–644. https://doi.org/10.1177/1090198110363884.

Biddle, S.J.H., Asare, M., 2011. Physical activity and mental health in children and adolescents: a review of reviews. Br. J. Sports Med. 45 (11), 886–895. https://doi.org/10.1136/bjsports-2011-090185.

Chen, T.-A., O'Connor, T.M., Hughes, S.O., et al., 2013. TV parenting practices: is the same scale appropriate for parents of children of different ages? Int. J. Behav. Nutr. Phys. Act. 10 (1), 41. https://doi.org/10.1186/1479-5868-10-41.

Choi, L., Liu, Z., Matthews, C.E., Buchowski, M.S., 2011. Validation of accelerometer wear and nonwear time classification algorithm. Med. Sci. Sports Exerc. 43 (2), 357–364. https://doi.org/10.1249/MSS.0b013e3181ed61a3.

Collins L, Lanza S. Latent Class and Latent Transition Analysis: With Applications in the Social, Behavioral, and Health Sciences, 2010.

Davison, K.K., Cutting, T.M., Birch, L.L., 2003. Parents' activity-related parenting practices predict girls' physical activity. Med. Sci. Sports Exerc. 35 (9), 1589–1595. https://doi.org/10.1249/01.mss.0000084524.19408.0c.

Davison, K.K., Li, K., Baskin, M.L., Cox, T., Affuso, O., 2011. Measuring parental support for children's physical activity in white and African American parents: The Activity Support Scale for Multiple Groups (ACTS-MG). Prev. Med. (Baltim). 52 (1), 39–43. https://doi.org/10.1016/J.YPMED.2010.11.008.

Davison, K.K., Gicevic, S., Aftosmes-Tobio, A., et al., 2016. Fathers' representation in observational studies on parenting and childhood obesity: a systematic review and content analysis. Am. J. Public Health 106 (11), 1980. https://doi.org/10.2105/AJPH.2016.303391a.

Donnelly, J.E., Hillman, C.H., Castelli, D., et al., 2016. Physical activity, fitness, cognitive function, and academic achievement in children: a systematic review. Med. Sci. Sports Exerc. 48 (6), 1223–1224. https://doi.org/10.1249/mss.0000000000000966.

Edwardson, C.L., Gorely, T., 2010. Parental influences on different types and intensities of physical activity in youth: A systematic review. Psychol. Sport Exerc. 11 (6), 522–535.

Edwardson, C.L., Gorely, T., 2010. Activity-related parenting practices and children's objectively measured physical activity. Pediatr. Exerc. Sci. 22 (1), 105–113.

Evenson, K.R., Catellier, D.J., Gill, K., Ondrak, K.S., McMurray, R.G., 2008. Calibration of two objective measures of physical activity for children. J. Sports Sci. 26 (14), 1557–1565. https://doi.org/10.1080/02640410802334196.

Gubbels, J.S., Kremers, S.P., Stafleu, A., et al., 2011. Association between parenting practices and children's dietary intake, activity behavior and development of body mass index: the KOALA Birth Cohort Study. Int. J. Behav. Nutr. Phys. Act. 8 (1), 18. https://doi.org/10.1186/1479-5868-8-18.

Hagenaars, J.A., McCutcheon, A.L., 2002. Applied Latent Class Analysis. Cambridge University Press.

Hnatiuk, J.A., Salmon, J., Hinkley, T., Okely, A.D., Trost, S., 2014. A review of preschool children's physical activity and sedentary time using objective measures. Am. J. Prev. Med. 47 (4), 487–497. https://doi.org/10.1016/j.amepre.2014.05.042.

Kaehler, L.A., Jacobs, M., Jones, D.J., 2016. Distilling common history and practice elements to inform dissemination: Hanf-Model BPT programs as an example. Clin. Child. Fam. Psychol. Rev. 19 (3), 236–258. https://doi.org/10.1007/s10567-016-0210-5.

Lloyd, A.B., Lubans, D.R., Plotnikoff, R.C., Morgan, P.J., 2015. Paternal lifestyle-related parenting practices mediate changes in children's dietary and physical activity behaviors: findings from the healthy dads, healthy kids community randomized controlled trial. J. Phys. Act. Heal. 12 (9), 1327–1335. https://doi.org/10.1123/jpah.2014-0367.

Loprinzi, P.D., Davis, R.E., 2016. Secular trends in parent-reported television viewing among children in the United States, 2001–2012. Child Care Health Dev. 42 (2), 288–291. https://doi.org/10.1111/cch.12304.

Masse, L.C., O'Connor, T.M., Tu, A.W., et al., 2016. Are the physical activity parenting practices reported by US and Canadian parents captured in currently published instruments? J. Phys. Act Heal. 13 (10), 1070–1078. https://doi.org/10.1123/jpah.2016-0012.

Morgan, P.J., Young, M.D., Lloyd, A.B., et al., 2017. Involvement of fathers in pediatric obesity treatment and prevention trials: a systematic review. Pediatrics 139 (2). https://doi.org/10.1542/peds.2016-2635.

Muthén L, guide BM applied researchers: user's, 2019 undefined. Mplus. statmodel.com. http://www.statmodel.com/virg_nov_course.shtml. Accessed June 6, 2019.

Neshteruk, C.D., Nezami, B.T., Nino-Tapias, G., Davison, K.K., Ward, D.S., 2009. The influence of fathers on children's physical activity: A review of the literature from 2009 to 2015. Prev. Med. (Baltim). 2017, 102. https://doi.org/10.1016/j.ypmed.2017.06.027.

Nylund, K.L., Asparouhov, T., Muthén, B.O., 2007. Deciding on the number of classes in latent class analysis and growth mixture modeling: A Monte Carlo simulation study. Struct. Equ. Model A Multidiscip. J. 14 (4), 535–569. https://doi.org/10.1080/10705510701575396.

O'Connor, T.M., Cerin, E., Hughes, S.O., et al., 2013. What Hispanic parents do to encourage and discourage 3–5 year old children to be active: a qualitative study using nominal group technique. Int. J. Behav. Nutr. Phys. Act. 10 (1), 93. https://doi.org/10.1186/1479-5868-10-93.

Ogden, C.L., Kuczmarski, R.J., Flegal, K.M., et al., 2002. Centers for disease control and prevention 2000 growth charts for the United States: improvements to the 1977 National Center for Health Statistics version. Pediatrics 109 (1), 45–60.

Pate, R.R., O'Neill, J.R., Liese, A.D., et al., 2013. Factors associated with development of excessive fatness in children and adolescents: a review of prospective studies. Obes. Rev. 14 (8), 645–658. https://doi.org/10.1111/obr.12035.

Piercy, K.L., Troiano, R.P., Ballard, R.M., et al., 2018. The physical activity guidelines for Americans. JAMA 320 (19), 2020. https://doi.org/10.1001/jama.2018.14854.

Suen, Y., Cerin, E., Barnett, A., Huang, W.Y.J., Mellecker, R.R., 2019. Associations of socio-demographic, family, and neighborhood factors with physical activity-related parenting practices among Hong Kong Preschoolers' parents. Matern. Child Health J. 23 (5), 678–691. https://doi.org/10.1007/s10995-018-2689-5.

Tandon, P.S., Zhou, C., Lozano, P., Christakis, D.A., 2011. Preschoolers' total daily screen time at home and by type of child care. J. Pediatr. 158 (2), 297–300. https://doi.org/10.1016/j.jpeds.2010.08.005.

Tang, L., Darlington, G., Ma, D.W.L., Haines, J., 2018. Guelph Family Health Study. Mothers' and fathers' media parenting practices associated with young children's screen-time: a cross-sectional study. BMC Obes. 5 (1), 37. https://doi.org/10.1186/s40608-018-0214-4.

Tein, J.-Y., Coxe, S., Cham, H., 2013. Statistical power to detect the correct number of classes in latent profile analysis. Struct. Equ. Modeling. 20 (4), 640–657. https://doi.org/10.1080/10705511.2013.824781.

Timmons, B.W., Leblanc, A.G., Carson, V., et al., 2012. Systematic review of physical activity and health in the early years (aged 0–4 years). Appl. Physiol. Nutr. Metab. 37 (4), 773–792. https://doi.org/10.1139/h2012-070.

Troiano, R.P., Berrigan, D., Dodd, K.W., Mâsse, L.C., Tilert, T., McDowell, M., 2008. Physical activity in the United States measured by accelerometer. Med. Sci. Sport Exerc. 40 (1), 181–188. https://doi.org/10.1249/mss.0b013e31815a51b3.

Trost, S.G., Loprinzi, P.D., 2011. Parental influences on physical activity behavior in children and adolescents: a brief review. Am. J. Lifestyle Med. 5 (2), 171–181.

Vaughn, A.E., Hales, D., Ward, D.S., 2013. Measuring the physical activity practices used by parents of preschool children. Med. Sci. Sport Exerc. 45 (12), 2369–2377. https://doi.org/10.1249/MSS.0b013e31829d27de.

Verloigne, M., Van Lippevelde, W., Maes, L., Brug, J., De Bourdeaudhuij, I., 2012. Family- and school-based correlates of energy balance-related behaviours in 10–12-year-old children: a systematic review within the ENERGY (EuropeaN Energy balance Research to prevent excessive weight Gain among Youth) project. Public Health Nutr. 15 (8), 1380–1395. https://doi.org/10.1017/s1368980011003168.

Ward, D.S., Vaughn, A.E., Bangdiwala, S.I., et al., 2011. Integrating a family-focused approach into child obesity prevention: Rationale and design for the My Parenting SOS study randomized control trial. BMC Public Health. 11 (1), 431. https://doi.org/10.1186/1471-2458-11-431.

Xu, H., Wen, L.M., Rissel, C., 2015. Associations of parental influences with physical activity and screen time among young children: a systematic review. J. Obes. 2015, 546925. https://doi.org/10.1155/2015/546925.

Yao, C.A., Rhodes, R.E., 2015. Parental correlates in child and adolescent physical activity: a meta-analysis. Int. J. Behav. Nutr. Phys. Act. 12, 10. https://doi.org/10.1186/s12966-015-0163-y.

Young, M.D., Lubans, D.R., Barnes, A.T., Eather, N., Pollock, E.R., Morgan, P.J., 2019. Impact of a father-daughter physical activity program on girls' social-emotional well-being: A randomized controlled trial. J. Consult. Clin. Psychol. 87 (3), 294–307. https://doi.org/10.1037/ccp0000374.

Zahra, J., Sebire, S.J., Jago, R., 2015. "He's probably more Mr. sport than me"–a qualitative exploration of mothers' perceptions of fathers' role in their children's physical activity. BMC Pediatr. 15, 101. https://doi.org/10.1186/s12887-015-0421-9.