Within-Subject Associations of Maternal Physical Activity Parenting Practices on Children's Objectively Measured Moderate-to-Vigorous Physical Activity

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Abstract

Objective Longitudinal within-subject (WS) associations of mothers' momentary assessed physical activity (PA) parenting practices were examined with children's objectively measured PA during the same 2-hr time frame. **Method** Mother-child dyads ($n = 189$) completed five ecological momentary assessment (EMA) measurement bursts over 3 years. During each 7-day burst, mothers EMA-reported their past 2 hr PA parenting practices (i.e., encouraging their child to be physically active, taking their child someplace to be physically active), and children ($M_{\text{age}} = 9.6$ years, $SD = 0.9$) wore an accelerometer to measure moderate-to-vigorous PA (MVPA). Two-part multilevel models were used, with zero portions representing not meeting MVPA and positive portions representing any MVPA, controlling for demographic covariates. Cross-level interaction terms of child sex and age with parenting were created to test moderation effects. **Results** When mothers reported taking their child to be physically active, children were more likely to get some MVPA ($b = -0.56$, $p < .001$). When mothers reported taking their child to be physically active more, children had higher levels of MVPA ($b = 0.24$, $p < .001$). When mothers reported encouraging their child to be physically active, children were less likely to get any MVPA ($b = 0.27$, $p < .05$). However, when mothers reported encouraging their child to be physically active more, children had higher levels of MVPA ($b = 0.29$, $p < .001$). These effects were not moderated by child sex or age. **Conclusions** WS variations of mothers' support for PA across the day were associated with changes in children's MVPA. Future research should consider promoting mothers' provision of support for increasing children's PA.

Key words: health behavior; parenting; parents; spina bifida.

Introduction

Child obesity rates continue to increase, with one out of three U.S. children currently categorized as overweight or obese (Skinner, Ravanbakht, Skelton, Perrin, & Armstrong, 2018). Promotion of energy expenditure through physical activity (PA) can have a positive impact on reducing obesity rates. National guidelines recommend children and adolescents accumulate 60 min of PA daily (US Department of Health and Human Services, 2008). However, the majority fail to meet these recommendations, with only 42.5% of all children of age 6–11 years meeting the PA guidelines. Furthermore, gender disparities in PA exist as evidenced by 36.1% of girls of age 6–11 years reporting meeting guidelines compared with 48.6% of boys. These percentages decline further as children age, with only 7.5% of children of age 12–15 years meeting the PA guidelines (National Physical Activity Plan Alliance, 2016).

Parents play a prominent role in ensuring their children meet PA recommendations. A growing body of evidence suggests that parental factors such as general parenting style, parenting practices, behavior modeling, logistic support, and verbal encouragement may be related to children's PA levels (Davison & Campbell, 2005; Xu, Wen, & Rissel, 2015). Two particularly important components of parental support of children's PA that have received attention are instrumental support and emotional support (Hutchens & Lee, 2018; Xu et al., 2015). Instrumental support for PA includes providing the child with opportunities to be physically active including access to activity-promoting equipment (e.g., footwear, safety equipment, play structure, balls, jump rope, and racket), facilitating registration in organized sports, and transporting the child for participation in organized sports or group play (Laird, Fawcner, Kelly, McNamee, & Niven, 2016). Emotional support includes ensuring the child knows the parent is responsive to the child's needs such as consoling the child during injury or loss of a match or game, encouraging the child to be physically active, and serving as a spectator while the child is engaged in an activity or sport (Laird et al., 2016).

Extant literature on the extent to which parent instrumental and emotional support influence children's PA has yielded mixed findings and suffers from methodological limitations. Cross-sectional research shows that encouraging a child to be physically active (i.e., emotional support for PA) and taking a child to be physically active (i.e., instrumental support for PA) is associated with higher levels of parent-reported PA in children (Heredia, Wanjit, Warren, & Evans, 2016; Pyper, Harrington, & Manson, 2016). However, randomized controlled trials promoting PA parenting practices showed no intervention effects on children's accelerometer-measured PA (Gerards et al., 2015; O'Connor, Hilmers, Watson, Baranowski, &

Giardino, 2013). In the cross-sectional studies, parent report of time children spent being physically active was used to assess whether children met PA guidelines (Pyper et al., 2016), and children's PA was operationalized as parent-reported number of times children engaged in sports, dance, or outdoor play (Heredia et al., 2016). Although these measures are proxies for objectively measured PA, they may not accurately represent active play, overestimating time spent in moderate-to-vigorous PA (MVPA). This is because parent report of child PA is limited by direct parent observation that relies on the parent being with their child, or parent recollection of children's activity with the potential of social desirability of parent responses (Morsbach & Prinz, 2006).

The few studies that have used objective measures to examine the associations between parental encouragement for PA and children's PA have reported mixed results. One cross-sectional study found a positive association between parental encouragement and accelerometer-measured child MVPA (Bradley, McRitchie, Houts, Nader, & O'Brien, 2011). However, another study using pedometers did not find any association between parent encouragement of PA and children's step count (Chiarlitti & Kolen, 2017). Studies that have used objective measures to examine the associations between transportation for PA and children's PA have reported positive results. Researchers found that transportation for PA was positively associated with child MVPA for authoritative, authoritarian, and permissive parenting styles (Langer, Crain, Senso, Levy, & Sherwood, 2014). Wilk, Clark, Maltby, Tucker, and Gilliland (2018) found that transportation for PA had a significant indirect effect on children's PA (Wilk et al., 2018). Using more objective measures to evaluate child PA will increase the validity and reliability of outcomes and support the conclusions drawn from examining associations between parent support for PA and child PA.

There is also a lack of research examining the within-day effects of PA parenting practices on children's PA. Between-subject (BS) examinations of parenting practices that occur only at one time point are unable to assess variations in parenting that occur over short periods of time (such as minutes or hours). Within-day assessments can determine contextual factors that affect the dynamics of parent support for children's PA that may lead to children's PA participation. Multiple daily assessments increase ecological validity and reduce social desirability of responses and recall bias because of reporting of parenting support for PA behaviors within a short reporting window. These limitations prevent researchers from understanding the sequence of events that occur and affect parenting support behaviors that may be most effective in increasing PA among children. Therefore, the current study examined whether within-subject (WS)

(i.e., intra-individual) changes in mothers' PA parenting practices were related to children's accelerometer-measured MVPA. To do this, we examined the relationships between mothers' ecological momentary assessment (EMA) reports of PA parenting practices on children's objectively measured PA during the same 2-hr time frame (Figure 1). Moderation effects of child sex and age were tested because of epidemiological evidence that consistently reports girls are less physically active than boys, and PA declines as children age (National Physical Activity Plan Alliance, 2016). Prior research has focused on examination of BSs effects of PA parenting practices on children's objectively measured and parent-reported PA. We hypothesize positive WS associations of PA parenting practices and children's PA, with no additional hypotheses noted.

Methods

The current study used five measurement bursts of intensive longitudinal data from $n = 189$ mother-child dyads (at first measurement burst) to $n = 124$ mother-child dyads (at fifth measurement burst) participating in the Mothers and Their Children's Health (MATCH) study, a prospective study examining the effects of mothers' stress on children's obesity risk. Measurement bursts were 7-day periods that occurred every 6 months over the course of 3 years. Inclusion criteria for mothers and children at baseline were (1) child is 8–12 years old, (2) mother has at least 50% child custody, and (3) both mother and child are able to read English or Spanish. Exclusion criteria for mothers and children at baseline were (1) currently taking medications for a psychological condition, (2) health issues that limit PA, (3) child enrolled in special education programs, (4) currently using oral or inhalant corticosteroids, (5) mother is currently pregnant, and (6) mother works more than 2 weekday evenings (e.g., between 5 and 9 PM) per week, or 8 hr or more on any weekend day.

Procedures

Complete study procedures are described in depth elsewhere (Dunton et al., 2015). In brief, participants attended a 90-min data collection session at either a local school or recreation center. During these sessions, mothers received MotoG Smartphones (Motorola Mobility, Chicago, IL) with the custom-designed MATCH study App (Google, Inc., Mountain View, CA) preinstalled on the phone, along with instructions for completing the 7-day EMA measurement burst. Children received Actigraph GT3X accelerometers (Actigraph Corp., Pensacola, FL), along with instructions for wearing the accelerometer during the measurement burst over the next 7 days. Additionally, mothers and children completed the anthropometric measures and paper questionnaires.

Mothers provided parental permission for their child to participate, along with written informed consent at each data collection session before each measurement burst. Children provided both verbal consent and written informed consent at each data collection session before each measurement burst. Institutional review boards at Northeastern University and the University of Southern California approved all study procedures.

Demographics

Mothers reported their age, race/ethnicity, education level, household income, work status, and number of children in the household, as well as their child's age. For the purposes of these analyses, full-time work status (working full-time vs. not working full time) and education (college-educated or higher vs. not college-educated) were dichotomized. Additionally, because of the fact that approximately half of mothers reported Hispanic/Latino ethnicity, this variable was also dichotomized for the purposes of these analyses.

Anthropometrics

Children's height (cm) and weight (kg) were measured in duplicate, with mean values computed. Centers for Disease Control and Prevention (CDC)-age and sex-adjusted body mass index (BMI) z -scores were calculated from children's height and weight data (Kuczmarski et al., 2000).

Ecological Momentary Assessment

At each measurement burst, mothers received multiple random EMA prompts daily, beginning either the same evening on the first day of the data collection session or the following day for a total of 7 days. On weekdays, EMA surveys were prompted during after-school hours, up to four times per day (between 3:00 PM and 10:00 PM). This time frame was chosen because of greater opportunity for the mother to interact with her child and report use of parenting practices for PA. On weekend days, EMA surveys were prompted up to eight times per day (between 7:00 AM and 10:00 PM). EMA-prompting schedules were based on participants' bedtimes and wake-up times, resulting in the potential for some participants to receive less than the maximum total of four times on weekdays (in afterschool hours) and eight times on weekends. Participants were instructed to continue their daily routines and respond to each prompt unless they were performing an incompatible activity (i.e., driving, bathing, water activity). Prompts were either audible (chime) or inaudible (vibrate), and signaled the participant to stop her current activity and answer the EMA survey, which took approximately 2–3 min to complete. At each EMA prompt, mothers were asked if they spent time with their child over the past 2 hr. If

Figure 1 Example of mother's weekday EMA prompting schedule (four random prompts from 3pm-10pm) aligned with child's accelerometer wear time (wake-up to bedtime)

they responded in the affirmative, a random sample of 60% of the following questions included the assessment of PA parenting practices using two items: (1) "In the past 2 HOURS, did you take your child someplace to be physically active?" and (2) "In the past 2 HOURS, did you encourage your child to be physically active?" Response options included "YES" (coded as "1") and "NO" (coded as "0").

Accelerometry

Children were instructed to wear the Actigraph GT3X accelerometer (Actigraph Corp., Pensacola, FL) on their right hip during all waking hours over 7 days, matching the same measurement burst as mothers' 7-day EMA. Accelerometers were only to be removed during bathing, water activities, and at bedtime. Accelerometer data had a sampling frequency of 30 Hz and were collected as continuous count data that were aggregated into 30 s epochs, with age-adjusted Freedson cutpoints for determining MVPA in youth (Freedson, Pober, & Janz, 2005). Non-wear time was categorized as 60 consecutive minutes of zero count epochs (Troiano et al., 2008). To be included in the analyses, each 2-hr window of accelerometer data contained at least 80 min of valid accelerometer wear.

Statistical Analyses

The association between mothers' EMA reports of PA parenting practices in the last 2 hr of children's accelerometer-measured MVPA within the same 2-hr time window was investigated via two-part mixed models using the "gsem" command in Stata 15 (StataCorp LLC, College Station, TX) (see [Supplementary Materials](#) for Stata code). Two-part models allowed for separation of the regression analyses into zero-portion (i.e., no MVPA) and continuous-portion (i.e., any MVPA), and were estimated concurrently in a single model. Mixed models were used to adjust for the clustering of observations (i.e., EMA prompts) nested within measurement bursts, nested within mothers (Raudenbush & Bryk, 1986). Owing to the complexity of analyzing a four-level model (observations nested within days nested within

measurement bursts nested within mothers), we controlled for weekend versus weekday as a dummy variable (weekend = 1) at the lowest level (Level 1) of predictors. Dichotomous EMA reports of PA parenting practices (i.e., took child somewhere to be physically active or encouraged child to be physically active) in the past 2 hr were the independent variable, and total minutes of children's accelerometer-measured MVPA in the past 2hr were the dependent variable. WS covariates included child age (taken at each measurement burst, subtracted from age at baseline), BMI z-score (at each measurement burst), study measurement burst, EMA chronological prompt number within the day (i.e., time of day), and weekend versus weekday. BS covariates included child sex, baseline-centered child age, mother's employment status (full-time vs. not) at baseline, mother's education (college graduate vs. not), Hispanic ethnicity (Hispanic vs. not), single-parent status (single parent vs. not) at baseline, and number of children in the household at baseline. Covariates such as mother's college degree, full-time employment, single-parent status, and number of children were tested in an exploratory manner because of the lack of research indicating that these variables are associated with PA levels in children. Two-way cross-level interaction terms were created with PA parenting practices EMA variables (WS) and child sex (BS). Two-way cross-level interaction terms were created with PA parenting practices EMA variables (WS) and child age at each measurement burst (WS). The interaction terms were then entered into the models one at a time to test the significance of the interaction. Post hoc analyses were conducted where the models were stratified by any significant interaction variables identified. Models also controlled for BS effects of the time-varying PA parenting practices variables. WS versions of the PA parenting practice predictors were created to indicate the deviation of each prompt from a mother's own mean (by using person-mean centering) at any given EMA prompt (Curran & Bauer, 2011). The number of Level 1 observations available across all measurement bursts (i.e., EMA prompts) is considered to be the unit of analysis for testing the hypothesized WS effects,

Table I. Descriptive Statistics: Mothers and Their Children's Health (MATCH) Study ($n = 189$ Mother-Child Pairs)

Variables	%
<i>Mother's demographic characteristics</i>	
Married or cohabitating	67.3
Race/ethnicity	
Hispanic/Latino	49.0
Income	
\$0-\$35,000	27.4
\$35,001-\$75,000	29.4
\$75,001-\$105,000	19.4
$\geq$ \$105,001	23.9
Employment	
<Full-time	57.6
Full-time	42.4
Education	
<College	31.4
College graduate	68.6
	<i>M (SD)</i>
Age, years	41.0 (6.20)
BMI	28.3 (6.24)
<i>Mother's physical activity parenting practices</i>	
Encourage to be physically active (BSs)	0.43 (0.238)
Take child to be physically active (BSs)	0.30 (0.199)
Encourage to be physically active (WSs)	0.02 (0.443)
Take child to be physically active (WSs)	0.00 (0.422)
<i>Child demographic characteristics</i>	
	%
Sex, girl	51.0
	<i>M (SD)</i>
Age, years	9.60 (0.913)
BMI z-score	0.53 (1.03)

Note. Possible scores for physical activity parenting practices are coded 0 for a response of "No" and 1 for a response of "Yes."

assuming nonrandomly varying slopes. With a Level 1 sample size of 13,117, there is adequate statistical power ($>.80$) to detect small effects.

Because MVPA data are often positively skewed with an inflated number of zeros, use of traditional linear mixed models that assume a normal distribution are not appropriate for analyses (Baldwin, Fellingham, & Baldwin, 2016). Thus, a two-part model was used that combines a logistic regression model for the zero portion of MVPA and a gamma regression model for the continuous, positive portion of MVPA (Baldwin et al., 2016; Olsen & Schafer, 2001; Tooze, Grunwald, & Jones, 2002). The odds of no activity is predicted by the logistic model and minutes of MVPA is predicted by the gamma model (Baldwin et al., 2016). Therefore, use of the two-part model yields two interpretations of the results: (1) the likelihood of no activity (zero portion); and (2) the expected amount of activity when the participant was active (positive portion).

Results

Participant Characteristics

Participant characteristics are reported in Table I. A total $n = 202$ mother-child dyads participated in the

MATCH study. Of these, data from $n = 189$ were available at baseline. The majority of mothers (67%) reported being married and nearly half reported Hispanic/Latino ethnicity (49.0%). Ages ranged from 26 to 57 years old, and BMI ranged from 16.8 to 57.2 kg/m². Among children, 51% were girls, ranged in age from 8 to 12 years old, and had a BMI z-score between -2.18 and 2.61 . Participant characteristics were consistent with those from the total number of dyads participating in the MATCH study.

Data Availability

The total possible number of mother-child dyads was 202, 169, 153, 154, and 153 (measurement burst #1, #2, #3, #4, and #5, respectively). Owing to missing data, the number of mother-child dyads with available data for analyses was 189, 153, 127, 136, and 124 (measurement burst #1, #2, #3, #4, and #5, respectively). Across the five measurement bursts, EMA completion rates for mothers were 79%, 78%, 69%, 73%, and 79% (measurement burst #1, #2, #3, #4, and #5, respectively). The total number of observations in each measurement burst was 3,509, 2,685, 2,224, 2,478, and 2,221 (measurement burst #1, #2, #3, #4, and #5, respectively). Data were analyzed using complete data. Missing values in the BS and WS variables were all omitted from analyses. If any of the WS variables were missing an observation, that observation was not included (i.e., observation-specific deletion). On the other hand, if a participant failed to report any of the BS variables, that participant's entire set of observations was omitted. All responses to the PA parenting prompts were included, which occurred in a random 60% of all EMA prompts.

We applied standard multilevel modeling, which can adequately handle missing values within a longitudinal data set under the assumption that our data are missing at random (Goldstein, 2011; Kwok et al., 2008). To test the possibility that our missing data were missing not at random, we identified and examined four major sources of missingness in our EMA data. The first source of missingness included missing PA parenting items because of participant attrition (up to 30% of dyads at any given measurement burst). There were no differences between the participants who dropped out and those who completed all the measurement bursts (70 vs. 128 dyads) in terms of demographics and PA parenting items in the model (p values ranged from .08 to .92). The second source of missingness included missing PA parenting items from EMA non-response (up to 31% of prompts at any given measurement burst). We identified 491 different missing EMA daily patterns by categorizing prompts as complete or incomplete cases for the set of EMA parenting questions. The majority of the missing patterns (484 of 491) had a frequency $<3\%$, indicating

Table II. Bivariate Correlations BSs (Shown Above the Diagonal) and WSs (Shown Below the Diagonal) of Covariates With Accelerometer-Measured MVPA of the Child (Child MVPA) and Physical Activity Parenting Practices (Encourage Child to Be Physically Active and Take Child Somewhere to Be Physically Active)

Wave	.355**	-.098	-.257**	.231**	-.049	.088	-.068	-.031	.164*	.016	.037	.059	-.111	-.024
.597**	Child	-.112	-.086	.052	-.088	.094	.006	-.023	.094	.104	.113	-.012	-.103	-.076
-.012	age	Child	.027	-.045	-.024	-.040	-.031	-.041	-.123	-.014	.014	.042	.106	.158*
.004	-.086	gender	Window	-.674**	.086	.012	.118	.046	-.162*	-.061	.004	-.122	-.014	.051
.231**	.052	.011	sequence	Weekend	-.002	-.008	-.127	-.088	.064	-.040	-.033	.025	.022	-.033
.005	-.042**	-.048**	.018*	.000	College	.040	-.123	-.038	-.276**	-.257**	-.369**	.038	-.233**	-.151*
.052**	.070**	-.037**	.002	-.003	grad	Full-time	.112	-.124	.031	.066	.046	-.012	-.160*	-.118
.000	.055**	-.004	.006	-.012	-.171**	work	Single	-.175*	.111	.312**	.142*	.043	.122	.061
-.071**	-.072**	-.078**	.006	-.004	.019*	parent	-.143**	Number of	-.027	-.028	-.045	.080	.202**	.232**
.040**	.022*	-.147**	-.021*	.008	-.274**	children	.119**	-.013	Mother	.364**	.254**	-.142*	.062	.005
.018*	.122**	-.062**	-.020*	.013	-.270**	BMI	.273**	-.034**	BMI	.340**	.098	.034	.099	.038
-.011	.040**	.031**	.001	-.005	-.423**	-.003	.135**	-.041**	.200**	.093**	Mother	-.023	.018	.108
.007	-.001	.024**	-.060**	-.005	.006	.010	.012	.040**	-.059**	.025**	Hispanic	Child	.022	.082
-.026	-.009	.004	.021	.018	.021	-.003	-.014	.011	-.009	-.017	-.012	MVPA	.104**	.829**
.012	-.002	.016	.007	.038*	.019	-.010	-.025	-.004	-.006	.001	.006	Encourage	.131**	.550**
												PA	.062	Take
														PA

* $p < .05$, ** $p < .001$.

Table III. Estimates With Standard Error (SE), 95% Confidence Intervals (CIs), and *p*-Values of the Two-Part Multilevel Regression Models With Mothers' EMA Reports of Physical Activity Parenting Practices Within the Past 2 hr Predicting Child's Accelerometer-Measured MVPA Within the Same 2-hr Window (*n*=2,492 Observations, 189 Mother-Child Dyads)

Parameter	MVPA		
	Estimate (SE)	95% CI	<i>p</i>
Fixed effects			
Zero portion			
Intercept	-2.698 (.394)	-3.470, -1.925	<.001
BSs			
Mean levels of taking child to be physically active	-.187 (.749)	-1.654, 1.280	.803
Mean levels of encouraging child to be physically active	-.019 (.596)	-1.186, 1.149	.975
WSs			
Deviations from mean levels of taking child to be physically active	-.559 (.140)	-.833, -.286	<.001
Deviations from mean levels of encouraging child to be physically active	.265 (.133)	.005, .525	.045
Positive portion			
Intercept	2.000 (.191)	1.624, 2.375	<.001
BSs			
Mean levels of taking child to be physically active	.146 (.422)	-.681, .972	.730
Mean levels of encouraging child to be physically active	-.304 (.336)	-.964, .355	.365
WSs			
Deviations from mean levels of taking child to be physically active	.240 (.059)	.124, .355	<.001
Deviations from mean levels of encouraging child to be physically active	.285 (.058)	.172, .398	<.001
Random effects			
Variance, σ^2 positive portion	.190 (.029)	.141, .257	
Variance, σ^2 zero portion	.341 (.087)	.206, .563	
Covariance, σ^2 positive portion	-.168 (.040)	-.246, -.091	

Note. A two-part multilevel model combines a logistic regression model for the zero portion of MVPA and a gamma regression model for the continuous, positive portion of MVPA. The odds of no MVPA is predicted by the logistic regression portion (zero portion) of the model. The minutes of MVPA during active times is predicted by the gamma regression portion (positive portion). WS covariates included child age (taken at each measurement burst, subtracted from age at baseline), BMI *z*-score (at each measurement burst), study measurement burst, EMA chronological prompt number within the day (i.e., time of day), and weekend versus weekday. BS covariates included child sex, baseline-centered child age, mother's employment status (full-time vs. not) at baseline, mother's education (college graduate vs. not), Hispanic ethnicity (Hispanic vs. not), single-parent status at baseline (single parent vs. not), and number of children in the household at baseline.

that a systematic missing pattern was unlikely. We further tested the two most salient missing patterns that had a frequency around 5% (5.3% and 4.9%) by including the two patterns as dummy variables in our model and found the results did not change (*p* values for the pattern variables ranged from .65 to .89). The third source of missingness was missing PA parenting items from the study design (only 60% of the random EMA prompts received the two parenting questions at any given measurement burst). Because this missingness was not because of participants' non-response (either by not answering or skipping/ignoring the parenting questions), it was considered ignorable. The fourth source of missingness included missing responses to the PA parenting items from incomplete EMA surveys. Because these missing values were so few (four occasions), they were not considered to be a potential source of bias in the model estimates (<0.01% of all EMA prompts).

WS Associations of PA Parenting and Children's MVPA

Results from the analyses examining bivariate correlations of all BS and WS variables used in the analysis are shown in Table II. Results from the analyses

examining the two-part mixed models are reported in Table III. The results from the zero portion of the model indicated that there was a significant WS effect of mothers' EMA reports of taking their child to be physically active on the likelihood of children's accelerometer-measured MVPA during the same 2-hr window ($b = -0.559, p < .001$). The negative value of the beta coefficient represents the inverse of the absence of MVPA (i.e., zero portion). Thus, when mothers reported taking their child to be physically active in the past 2 hr, children were more likely to engage in some (vs. no) MVPA during the same 2-hr window. There was a marginally significant WS effect of mothers' EMA reports of encouraging their child to be physically active in the past 2 hr on the likelihood of children's accelerometer-measured MVPA during the same 2-hr window ($b = 0.265, p = .045$). The positive value of the beta coefficient represents the inverse of the presence of MVPA (i.e., positive portion). Thus, when mothers reported encouraging their child to be physically active in the past 2hr, children were less likely to engage in some (vs. no) MVPA during the same 2-hr window. The results from the positive portion of the model (i.e., among 2-hr windows with at least some child MVPA) indicated that there were

significant EMA WS effects of mothers' reports of taking their child to be physically active ($b = 0.240$, $p < .001$) and encouraging their child to be physically active ($b = 0.285$, $p < .001$) in the past 2 hr on children's accelerometer-measured MVPA during the same 2-hr window. Thus, when children engaged in at least some MVPA during any given 2-hr window, those levels of MVPA were higher when mothers reported taking their child to be physically active or encouraging their child to be physically active within the same 2-hr window.

The intercept estimate for the positive part-gamma model is 2.000, which indicates that for children who had some MVPA, the average amount of MVPA for a child whose mother did not take them anywhere or encourage them at any point during any measurement burst (i.e., all WS and BS predictors = 0) was 2.000 on the model scale, with a data-scale mean MVPA of 7.39 min within the 2 hr before the prompt, $\exp(2.000) = 7.3891$. The WS fixed effect of 0.240 for taking their child to be physically active represents a 27% expected increase in MVPA when they take their child someplace to be physically active more than their usual level, that is, $\exp(.2395747) = 1.270709$. The WS fixed effect of 0.285 for encouraging their child to be physically active represents a 32% expected increase in MVPA when they encourage their child someplace to be physically active more than their usual level, that is, $\exp(.2851542) = 1.329967$.

There were no significant BS effects for mothers taking their child to be physically active or encouraging their child to be physically active in either the zero versus nonzero (or positive) portion of the model. Intraclass correlation coefficients (ICCs) of the WS predictors (i.e., encouraging the child to be physically active and taking the child someplace to be physically active) were calculated. The ICC for encouraging the child to be physically active was 0.05, indicating that only 5% of the variance was contributed by the BS differences among mothers (and the remaining 95% of the variance was contributed by WS differences). Similarly, the ICC for taking the child someplace to be physically active was 0.06, indicating that only 6% of the variance was contributed by the BS differences among mothers (and the remaining 94% of the variance was WS differences). The two-way interaction terms with PA parenting practices EMA variables and child sex and age were all not significant.

Discussion

The current study examined the longitudinal relationships between mothers' EMA report of parenting practices to support PA (i.e., encouraging their child to be

physically active and taking their child to be physically active) and children's accelerometer-measured MVPA within the same 2-hr window. Children whose mothers reported taking their child somewhere to be physically active were more likely to perform MVPA. However, children whose mothers reported encouraging their child to be physically active were less likely to perform MVPA. Children who performed any MVPA had higher levels of MVPA when their mothers reported taking their child somewhere to be physically active or encouraging their child to be physically active. Examination of these WS associations enables greater understanding of the short-term effects of PA parenting practices on children's immediate PA. Because taking a child somewhere to be physically active will result in a child getting any MVPA (as compared to encouraging a child to be physically active), this could contribute to overall accumulation of PA, and a greater potential for meeting PA guidelines. Because encouraging a child to be physically active and taking a child somewhere results in more MVPA among active children, this suggests that parent support for PA may result in maintaining higher MVPA levels and potentially contribute to longer, more sustained bouts of PA, positively affecting children's cardiovascular fitness (Manley, 1996).

Previous research has not examined the within-day effects of PA parenting on children's MVPA. However, results from cross-sectional research examining BS effects support the majority of the current findings. One cross-sectional study created a sum score of parent support for PA that included parent encouragement, parent transportation for PA, parent modeling of PA, and watching the child participate in PA. Results indicated that parent support for PA was positively associated with children's objectively measured activity levels (Forthofer, Dowda, McIver, Barr-Anderson, & Pate, 2016). Another study showed that parental emotional support (encouragement of PA, show approval for PA, and watch child participate in PA) was positively associated with Hispanic and White children's report of PA over the previous week (Heredia et al., 2016). The current study had a large percentage (49%) of Hispanic mothers, and thus, their parental support practices may consist of more components of family cohesion or *familismo*, which has been shown to positively affect children's PA levels (Ornelas, Perreira, & Ayala, 2007). Additionally, the current study had a large percentage of participants reporting high socioeconomic status, with 43% earning at least \$75,000 annually. Children from families with higher incomes have greater access to play equipment and more opportunities for PA compared with children from homes with lower socioeconomic status (Tandon et al., 2012). Families with higher incomes may live in safer neighborhoods where children can go

outside to be physically active. Similarly, those with higher incomes may be able to financially afford the costs of organized activity or sports participation.

Results from the current study indicate that children whose mothers reported encouraging their child to be physically active were less likely to perform MVPA. However, children who performed any MVPA had higher levels of MVPA when their mothers reported encouraging their child to be physically active. This lack of agreement in findings may indicate that encouragement of PA may not be as effective when a child is not active. Specifically, encouragement may be misinterpreted as a negative form of persuasion to be physically active, such as nagging (Robbins, Talley, Wu, & Wilbur, 2010). In contrast, taking a child someplace to be physically active may provide a way for parents to demonstrate their support of PA, resulting in a child to be more likely to perform MVPA.

Two-way interaction terms with the parent support EMA variables and child sex were not significant in the present study. Although results from the present study are corroborated by previous studies that did not report gender differences (Hutchens & Lee, 2018), some research indicates differential findings by gender for the effects of parental encouragement for PA and transportation for PA on children's PA (Bradley et al., 2011; Forthofer et al., 2016; Jago et al., 2011; Seabra et al., 2013; Telford, Telford, Olive, Cochrane, & Davey, 2016). Results from one study with mothers found that boys who were encouraged more often to perform PA and girls who were taken somewhere to be physically active had higher levels of MVPA (Bradley et al., 2011). In another study conducted with mothers and fathers, greater maternal support for PA was associated with more PA among girls, while greater paternal support was associated with more MVPA among boys (Jago et al., 2011). The current study did not include fathers, which may have contributed to the lack of gender differences. Although child participants in these studies were of a comparable age with the children in the present study, ethnic diversity within the samples studied was limited because of participation from primarily higher-income U.S. Caucasian (~80%) parents and their children (Bradley et al., 2011), and children from the U.K. (Jago et al., 2011), Portugal (Seabra et al., 2013), and Australia (Telford et al., 2016). Forthofer et al. (2016) studied a racially diverse sample but limited their sample to higher-income participants of age 10–11 years (Forthofer et al., 2016). The lack of findings within the current study may be because of the ethnic and socioeconomic diversity within the sample because different racial and ethnic groups hold different goals for children's energy-balance behaviors and value different parenting practices (Chao, 2000; Cheah, Leung, & Zhou, 2013; Harris & Ramsey, 2015).

Two-way interaction terms with the parent support EMA variables and child age were not significant in the present study. Although age was significant in the model (data not shown), the lack of an interaction suggests that there is no indication that age is attenuating the association between parental support and children's activity. This has implications for understanding how parents influence children's behaviors as they transition from childhood to adolescence. Based on these results, mothers' PA parenting practices continue to influence children's PA behavior, even when they are older and more autonomous. Previous longitudinal research has found significant bidirectional associations among young children's PA and mothers' PA parenting practices (Sleddens, Gubbels, Kremers, van der Plas, & Thijs, 2017). Mothers' support for children's PA at age 5 was associated with more MVPA at age 7 and children's PA at age 5 was associated with more parental support for PA at age 7 (Sleddens et al., 2017). These findings, taken together with the results from the current study, suggest that there may be a positive feedback loop in which parents' support for PA at any point in time increases children's PA at a subsequent point in time, which results in greater parent support for PA.

Strengths of the present study include the use of accelerometers to objectively measure children's MVPA levels over a 3-year period during children's late childhood. Additionally, the use of EMA as a real-time method of data capture for mothers' reports of their support for PA behaviors allows for examination of microtemporal processes that occur throughout the day. This information is crucial for the development of intervention strategies that target increasing or maintaining children's PA levels as they age. An additional strength is that EMA reduces recall and social desirability biases because of the reporting of behaviors when they occur and allows for greater generalizability, as the reporting of behaviors occurs in participants' natural environment.

This study, however, is not without limitations. While accelerometers are routinely used to capture MVPA, they cannot distinguish the context and location in which activity occurs. Thus, the results can only inform on maternal influence on overall body movement, and not the types of activities performed. Mothers' objectively measured MVPA levels 2 hr before their EMA prompt were not included in the analyses, preventing us from studying whether parent modeling of MVPA also played a role in children's PA levels. Additionally, limitations of using EMA include measurement reactivity, issues with acceptability and compliance, and missing data. Two EMA PA parenting practices items were used to assess parent support for children's PA, which may not fully capture instrumental and emotional support parents provide. The non-statistically significant results for the moderation

analyses that we found do not necessarily imply that the effect is absent. Instead, we may not have enough statistical power to detect them, and are thus potentially committing a Type II error (i.e., failing to detect an effect when one exists). The PA parenting EMA questions did not ascertain whether parents transported children to structured activities (e.g., organized sports and sports team activity) versus more flexible PA activities (e.g., park, recreation centers). Parents were not given definitions of “encouraging” their child to be physically active or “taking the child someplace” to be physically active, and therefore, different interpretations may have influenced variation in responses. Parents who observe their children engaged in PA may be more likely to report encouraging their child to be physically active. Missing EMA and accelerometer data may be nonrandom (e.g., greater on weekends, certain times of the day, and for certain types of people) because of competing priorities or performing tasks that make response to the prompt incompatible. Additionally, this study was restricted to mothers’ reports of PA parenting practices regarding their elementary-aged children, and the sample studied was nearly half Hispanic. Thus, results may not generalize to fathers or other caregivers from racially diverse populations with younger (pre-school-aged) or older children (high school-aged).

Conclusions

Mothers’ PA parenting practices are associated with increases in child MVPA. Children who are taken somewhere to be physically active are more likely to participate in MVPA and active children who are encouraged to be physically active or who are taken to be physically active get more MVPA. Implications for future just-in-time interventions include event-contingent prompting of parental support during times children are presently engaged in MVPA so that they may maintain or engage in greater levels of MVPA during these active episodes and prompting parental support during times children are not engaged in MVPA, so they can initiate MVPA. Benefits of timing parents’ provision of support for promoting children’s PA may ultimately help children meet PA guidelines and improve cardiovascular fitness.

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