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REGULAR ARTICLE

# Within-Subject Effects of Stress on Weight-Related Parenting Practices in Mothers: An Ecological Momentary Assessment Study

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**Abstract**

***Background*** Stress may compromise parenting practices related to children's dietary intake, physical activity, and sedentary behavior.

***Purpose*** The current study used Ecological Momentary Assessment (EMA) to examine microtemporal sequences underlying maternal stress and subsequent weight-related parenting practices.

***Methods*** Mothers ($n$ = 199) of children aged 8–12 years participated in two separate 7-day waves of EMA with up to eight randomly prompted surveys per day during children's nonschool time. EMA items assessed stress and weight-related parenting practices.

***Results*** When mothers reported experiencing greater stress than usual, they subsequently engaged in less physical activity parenting (e.g., encouraging physical activity; $p < .05$) and more sedentary screen behavior parenting (e.g., limiting TV/video games; $p < .05$) over the next 2 hr.

***Conclusions*** Addressing within-day variations in maternal stress may be an important component of parent-focused child obesity prevention interventions.

**Keywords** Ecological momentary assessment • Weight-related parenting • Maternal stress • Physical activity • Sedentary behavior • Dietary intake

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## Introduction

Increasing rates of overweight and obesity [1] pose serious health risks for children [2]. Late childhood is a particularly vulnerable period of rapid developmental and hormonal change characterized by rapid fat accumulation as children go through a phase of adiposity rebound [3]. Currently, over a third of U.S. children aged 6–11 years are overweight or obese, putting them at elevated risk for serious metabolic and cardiovascular disorders [4–6]. Parents are thought to have a significant influence over the physical activity and eating behaviors of their children [7]. However, family-based intervention programs have had only modest success at reducing obesity risk, and intervention outcomes using parents as agents of change for pediatric obesity have been mixed [8].

Psychological stress has been posited as an important factor that may compromise effective family functioning—triggering behaviors that increase risk of obesity in children [9]. Psychological stress occurs when perceived demands exceed personal and social resources to meet those demands [10]. As maternal employment rates have risen dramatically in the past few decades [11], the struggle to balance work and family demands can elevate psychological stress in mothers [12]. Nationally, over one-third of mothers reported extremely high levels of stress when compared with only one-quarter of fathers [13]. Although maternal stress has been implicated in contributing to obesity in children [14], stress reduction is not typically incorporated in family-based interventions to reduce obesity [15].

Maternal stress may compromise parenting practices related to children's dietary intake and physical activity, and thereby increase children's obesity risk. Elevated levels of stress experienced by mothers may deplete emotional and cognitive resources necessary to plan, initiate, and carry out effective parenting practices such as limiting or monitoring children's unhealthy behaviors and

modeling or encouraging healthy behaviors [16]. Greater stress also increases personal preference for palatable foods [17] such that mothers experiencing higher stress may feed their children the same high fat foods that they are preparing for themselves. Stress may also negatively affect mothers' capacity to support and promote children's physical activity. Higher levels of parent mental distress are associated with decreased parental involvement and encouragement [18], which may lead to reduced energy expenditure in children, as children may naturally gravitate to sedentary activities during low parental oversight [19, 20]. Maternal stress may additionally lead to poor role modeling of physically active behaviors [21]. Taken together, these studies provide support for the role of parenting practices in explaining the relationship between maternal stress and children's obesity risk.

Cross-sectional and longitudinal studies of stress and parenting often focus on the person as the primary unit of analysis [22]. Although this approach can examine interindividual (i.e., between-person) effects, it is unable to determine whether there also are intraindividual (i.e., within-person) effects that operate at finer time scales (e.g., across minutes or hours). The failure to account for intraindividual variation is akin to committing an ecological fallacy—whereby inferences about the effects of variables at lower-level units of analysis are based solely upon aggregate statistics collected for a higher unit of analysis [23], potentially obscuring the true relationships. For instance, stress levels and parenting practices may vary across the day [24]. Yet, between-person analyses of usual levels of these constructs may conceal temporal variations.

To address these limitations, the primary aim of the current study was to use Ecological Momentary Assessment (EMA) to examine within-subject (WS) effects of maternal stress on subsequent weight-related parenting practices. It was hypothesized that when mothers experienced greater stress than usual, they would engage in fewer healthy weight-related parenting practices (e.g., encouraging children to be physically active, limiting sedentary screen time, preparing fruit and vegetables, and limiting high fat/high sugar foods) over the next 2 hr. A follow-up exploratory goal was to examine which type of stressor (e.g., work at home, work at a job, tension with a spouse, and tension with children) was associated with subsequent weight-related parenting practices. The secondary aim was to examine the bidirectional effects of weight-related parenting practices on subsequent maternal stress.

## Methods

### Overview

The current analyses used data from the Mothers' and Their Children's Health (MATCH) study [25], which is a longitudinal investigation of parenting factors and obesity in a sample of mothers and children. The study employed a nonexperimental, case-crossover design. In case-crossover designs, a participant serves as his or her own control to assess the within-person effects of variability in exposure on a repeatedly measured outcome [26]. Each wave of data collection spanned 1 week with up to eight assessments per day. To maximize the number of EMA prompting occasions included to detect WS effects, the current analyses used data from the first two waves of available data, which were separated by 6 months.

### Participants

Participants included ethnically-diverse mothers of 8- to 12-years-old children recruited from public elementary schools and after-school programs in the greater Los Angeles metropolitan area. Families were contacted through informational flyers and in-person research staff visits to schools and community events. Recruitment materials described the purpose of the study as to examine how mothers' moods and behaviors affect children's daily physical activity and food intake. The inclusion criteria were as follows: (a) child in the 3rd–6th grade, (b) mother has at least 50% child custody, and (c) both mother and child are able to read English or Spanish. Exclusion criteria for mother or child were as follows: (a) currently taking medications for thyroid function or psychological conditions, (b) health issues that limit physical activity, (c) enrolled in special education programs, (d) currently using oral or inhalant corticosteroids for asthma, (e) pregnancy, (f) child classified as underweight by a body mass index (BMI) percentile < 5% adjusted for sex and age, or (g) mothers who work more than two weekday evenings (between the hours of 5–9 pm) per week or more than 8 hr on any weekend day. The study targeted 3rd–6th grade children because it is a time of rapid weight gain [27]. Mothers taking medications for thyroid function, psychological conditions, and asthma (i.e., corticosteroids) were excluded because these contain substances that can interfere with salivary cortisol levels, which was a biomarker assessed in the larger MATCH study.

### Procedures

At each data collection wave, mothers attended an in-person data collection session at a local school or community center where they completed a paper-and-pencil questionnaire, underwent anthropometric assessments, and received instructions for the smartphone EMA application (app). EMA data were collected through a custom software app for smartphones running the Android

operating system (Google Inc., Mountainview, CA). EMA data from smartphones were wirelessly uploaded and stored on a secure internet-accessible server, where investigators could monitor compliance. Mothers who owned Android smartphones downloaded the EMA app and completed the EMA surveys directly from their personal phones. Mothers who owned iPhones or who did not own a smartphone were loaned a Moto G (Motorola Mobility, Chicago, IL) smartphone. The EMA app was available in English or Spanish for mothers.

EMA data were collected across the week following the data collection session. Each mother received random EMA prompts after 5:00 pm on the day of the data collection session (day 1), across the next 6 complete days (days 2–7), and up until 5:00 pm on the last day (day 8). During this period, participants were asked to proceed with their daily routines as normal. On weekend days, EMA surveys were prompted up to eight times per day (between 7:00 am and 9:30 pm) at random times spaced approximately 2 hr apart. On weekdays, EMA surveys were prompted up to four times per day (between 3:00 pm and 9:30 pm) at random times spaced approximately 2 hr apart. This prompting frequency was chosen to maximize the likelihood of capturing WS variability in the exposures and outcomes of interest while minimizing participant burden and recall errors. Upon being prompted by the app with chimes and/or vibration, participants were instructed to stop their current activity and complete a short EMA survey on the touch screen of the phone. This process required about 2 min. If no entry was made, the application emitted up to two reminder signals at 3 min intervals. After this point, the EMA program became inaccessible until the next random prompt a few hours later. Participants were instructed to ignore signals that occurred during incompatible activities (e.g., driving, sleeping, and bathing) and had the option of customizing their sleep and wake times within the app so that EMA prompts did not occur when they were sleeping. Mothers provided informed consent and were given $100 for each complete assessment wave. Procedures were approved by the Institutional Review Boards at the University of Southern California and Northeastern University.

## Measures

### *Maternal stress*

Maternal stress was measured using three sets of items: feeling stressed, perceived stress, and exposure to specific stressors. The feeling stressed construct, representing the emotional aspect of stress, was assessed using one item, "How stressed are you feeling right now?" with responses ranging from 1 = "Not at all" to 4 = "Extremely." The perceived stress construct, representing the cognitive aspects of stress, was measured using two items adapted from the Perceived Stress Scale (PSS) [28]. These items asked, "How certain do you feel that you can deal with all the things that you have to do right now?" and "How confident do you feel about your ability to handle all of the demands on you right now?" There were four response options ranging from 1 = "Not at all" to 4 = "Extremely." Exposure to specific stressors was assessed using items adapted from the Daily Hassles Scale [29], addressing work, home, and family domains. Mothers were asked, "Since you woke up this morning [first prompt of the day]/Over the last 2 hours [all subsequent prompts], which of these things caused you stress? (Choose all that apply)." Responses included the following: "Work at home," "Work at a job," "Demands made by your family," "Tension with a coworker," "Tension with a spouse," "Tension with your children," and "Something else." In contrast to feeling stressed and perceived stress items, which assessed the concurrent levels of these constructs (i.e., "right now"), participants retrospectively reported exposure to stressors that occurred across the "last 2 hours." These constructs represent relatively infrequent discrete events that would have very limited occurrence if assessed using the former method. A count score was created for the number of specific stressors indicated at each prompt ranging from 0 to 7. Prior to analyses, a total maternal stress score at each EMA prompt was calculated by taking the sum of the standardized values for feeling stressed, perceived, stress, and number of stressors. For the total maternal stress scale, the within- and between-subject (BS) internal consistencies (ω's) were .77 and .74, respectively.

### *Weight-related parenting practices*

Mothers were also asked "Over the last 2 hours, have you spent time with your child (together in the same location)?" If the answer to this question was "yes," then the EMA app followed a branching sequence of items assessing weight-related parenting practices for children's [1] sedentary screen time [2], unhealthy eating [3], healthy eating, and [4] physical activity based on the Parenting Strategies for Eating and Activity Scale (PEAS) [30]. Each of these four weight-related parenting constructs was assessed in a randomly selected 60% of EMA prompts to limit the length of the EMA survey. To assess sedentary screen and unhealthy eating parenting, mothers were asked, "Over the last 2 hours, has your child asked to (insert target behavior)." Target behaviors included [1] "watch TV or videos or play video games" (i.e., sedentary screen time) and [2] "eat any chips, fries, pastries, sweets, or candy" (i.e., unhealthy eating). Response options and coding were as follows: "Yes, and I allowed it" = 0; "Yes, and my spouse/partner allowed it" = 0; "Yes, but I/we did not allow it" = 1;

"No, but did so without my permission" = 0; and "No, has not asked" = missing. For items to which mothers responded, "Yes, but I/we did not allow it" and "No, has not asked;" the branching sequence terminated. For all other responses, mothers were asked a follow-up question assessing limiting of that behavior: "Over the last 2 hours, have you tried to limit your child's (insert target behavior)" with response options and coding, "Yes" = 0.5 and "No" = 0. Responses to these two items were summed (and multiplied by 10 to rescale for ease of interpretation) for total sedentary screen time and unhealthy eating parenting scores, respectively, ranging from missing = child did not ask, 0 = allowed and did not limit, 5 = allowed and limited, and 10 = did not allow.

To assess physical activity parenting, mothers were asked, "Over the last 2 hours, have you encouraged your child to be physically active?" ("Yes" = 1 or "No" = 0) and "Over the last 2 hours, have you taken your child to a place to be physically active?" ("Yes" = 1 and or "No" = 0). Furthermore, to measure healthy eating parenting, mothers were asked, "Over the last 2 hours, have you encouraged your child to eat any fresh fruits or vegetables?" ("Yes" = 1 or "No" = 0) and "Over the last 2 hours, have you cooked or prepared any fresh fruits or vegetables for your child to eat?" (Yes" = 1 or "No" = 0). Responses to each of these two-item sets of questions were summed and averaged (and multiplied by 10 to rescale for ease of interpretation) for total physical activity and healthy eating scores, respectively, ranging from 0 to 10 with higher scores representing more parenting behaviors reported in the past 2 hr.

### *Anthropometric assessments*

Height and weight were measured from mothers in duplicate using an electronically calibrated digital scale (Tanita WB-110A) and professional stadiometer (PE-AIM-101) to the nearest 0.1 kg and 0.1 cm, respectively. BMI, $kg/m^2$ and weight status categories were created (underweight is <18.5, normal weight is ≥18.5 and <25, overweight is ≥25 and < 30, and obese is ≥30).

### *Demographic factors*

Mothers completed paper questionnaires assessing immigrant status (immigrant vs. nonimmigrant), days of childcare per week (2 days or less vs. 3 or more days), childcare with grandparent (yes vs. no), childcare with afterschool program (yes vs. no), household type (single-parent vs. dual-parent/multigenerational), marital status (married vs. not married), educational level (college graduate vs. not college graduate), ethnicity (Hispanic vs. not-Hispanic), child's ethnicity (Hispanic vs. not-Hispanic), annual household income (<$35,000; $35,001–$75,000; $75,001–$105,000; ≥$105,001), employment status (work full-time vs. not work full-time), child's sex, age, child's age, household size, and number of children at home.

## Data Analyses

To test the primary aim, the data were restructured in a lagged manner such that total stress at any given prompt (time t) (e.g., 3 pm) was linked to the parenting practices variables at the subsequent prompt (time t + 1) approximately 2 hr later (e.g., 5 pm). Thus, total stress data assessed at the last prompt of the day and parenting practice data assessed at the first prompt of the day were excluded from analyses. Furthermore, stress data were also excluded from analyses when they were linked to subsequent prompts in which [1] mothers answered "No" to the item asking whether they had spent time with their child in the past 2 hr and [2] parenting items were not assessed because of the random item inclusion EMA programming scheme (i.e., each parenting construct was included in a randomly selected 60% of EMA prompts as described above). To explore bidirectional effects, parenting practices at any given prompt (time *t*) were linked to total stress at the subsequent prompt 2 hr later (time $t + 1$).

Data were analyzed with multilevel linear regressions in SAS PROC MIXED, which adjust the standard errors for clustering of EMA observations (level 1) within participants (level 2) [31]. To test the primary aim, separate models tested the following outcome variables [1]: physical activity parenting [2], sedentary screen parenting [3], healthy eating parenting, and [4] unhealthy eating parenting. Each model entered the total stress score as the main predictor variable, which was disaggregated into BS (Level-2, person) and WS (Level-1, prompt) versions (i.e., partitioning the variance) [32]. The BS version represents the individual mean deviation from the grand mean, and the WS version represents deviation from one's own mean at any given EMA prompt [33]. BS coefficients were included in the statistical model to control for person-level effects. Follow-up exploratory analyses were conducted for the primary aim, which examined the effects of each type of stressor (e.g., work at home, work at a job, tension with a spouse, and tension with your children) on each type of parenting practice through a series of separate models. Given the exploratory nature of these analyses, adjustments for multiple comparisons in models testing study objectives were conducted using the Holm–Bonferroni method which controls for the family-wise error rate (i.e., Type I error [34]). To test the secondary aim, analyses included each of the four parenting practices as predictors of subsequent stress in separate models.

The following list of covariates was screened to determine which ones should be included in the multivariate multilevel linear regression models: immigrant status, days of childcare per week, childcare with grandparent, childcare with afterschool program, household type, marital status, educational level, ethnicity, child's ethnicity, annual household income, employment status (work full-time vs.

not work full-time), age, BMI, household size, number of children at home; and child age and sex. Each covariate was tested in a separate univariate multilevel linear regression model (i.e., no other predictors included) for each of the four outcomes. Covariates demonstrating significant associations ($p < .05$) with a target outcome variable were subsequently included in the final multiple multilevel linear regression model for that specific outcome. Thus, each of the final multiple multilevel linear regression models included a different set of covariates. However, all models controlled for time of day and weekend day versus weekday. Since data were combined across waves, all analyses controlled for wave (1 or 2).

## Results

### Participants

Of the 464 mother-child dyads initially expressing interest in the study, 132 dyads could not be reached by phone for eligibility screening, and 22 dyads declined to be screened for eligibility. Of the 310 dyads screened, 62 dyads did not meet eligibility criteria. Of the remaining 248 dyads who met eligibility criteria, 46 dyads either did not attend their initial enrollment session or were no longer interested in the study. A total of 202 mother-child dyads initially enrolled in the study. Three mothers did not report being with their child during any EMA prompts during either of the first two waves of data collection and were excluded from analyses, leaving a sample of 199 mothers. Of these mothers, $n = 194$ had EMA data at wave 1, $n = 162$ had EMA data at wave 2, and $n = 157$ had EMA data at both waves. Mothers were retained for analyses if they had at least one wave of EMA data.

Demographic information for the analytic sample of mothers ($n = 199$) is shown in Table 1. At wave 1, mothers ranged in age from 24 to 57 years ($M = 41.0$, $SD = 6.2$) and children were 8–12 years ($M = 9.6$, $SD = 0.9$). About half of mothers were Hispanic, and about 30% were born outside of the USA. A majority had graduated from college and worked full-time. Fewer than a quarter of mothers reported living in a single-parent household, and about a quarter of mothers had an annual household income of less than $35,000. About half of the children were female. Mothers had a median of 2.0 (interquartile range = 2.0–3.0) children.

**Table 1** Participant characteristics ($N = 199$) at wave 1

| Variable | *n* (%) |
|---|---|
| Childcare with grandparent | |
| Yes | 99 (49.8) |
| No | 100 (50.3) |
| Childcare with afterschool program | |
| Yes | 91 (45.7) |
| No | 108 (54.7) |
| Type of household | |
| Single parent | 45 (22.6) |
| Not single parent | 154 (77.4) |
| Mother education level[a] | |
| Not college graduate | 77 (38.7) |
| College graduate | 116 (58.3) |
| Mother ethnicity | |
| Hispanic | 97 (48.7) |
| Non-Hispanic | 102 (51.3) |
| Annual household income[a] | |
| Less than $35,000 | 54 (27.1) |
| $35,001–$75,000 | 58 (29.2) |
| $75,001–$105,000 | 39 (19.6) |
| $105,001 and above | 47 (23.6) |
| Mother employment status[a] | |
| Work full-time | 111 (55.8) |
| Not work full-time | 84 (42.2) |
| Child sex | |
| Male | 97 (48.7) |
| Female | 102 (51.3) |
| Mother BMI | |
| Underweight | 3 (1.5) |
| Normal | 62 (31.2) |
| Overweight | 64 (32.2) |
| Obese | 64 (32.2) |

[a]Data missing on variable.

### Data Availability

During the assessments, mothers answered 8,495 out of 10,680 (mean across persons = 78.93% [range 0%–100%]) delivered EMA prompts. On average, each mother answered 32.0 ($SD = 13.2$) EMA prompts combined across both waves. EMA compliance did not differ by day of the week or by wave. Average reported perceived stress across all days was unrelated to EMA compliance rates. Of the answered EMA prompts, $n = 2,051$ were excluded when total stress was assessed at the last prompt of the day and could not be matched to subsequent parenting practices data, and $n = 1,634$ were excluded when parenting practices were assessed at the first prompt of the day and could not be matched to prior total stress data. Furthermore, observations were also excluded from analyses when mothers answered "No" to the item asking whether they had spent time with their child in the past 2 hr ($n = 617$), and when parenting items were not assessed because of the random item exclusion EMA programming scheme ($n = 772$). Mothers were further excluded from individual statistical models due

to missing demographic data, leaving analytic samples sizes of $n$ = 556–1,739 observations (i.e., EMA prompts) at Level 1 and $n$ = 153–194 mothers at Level 2 depending on the outcome of interest.

### Descriptive Statistics

For the EMA items assessing specific stressors, data were as follows for the average person-level percent of answered EMA prompts that reported each stressor: demands made by family ($M$ = 13.8%, $SD$ = 16.1%, range = 0%–81.8%), work at a job ($M$ = 11.1%, $SD$ = 14.3%, range = 0%–100%), tension with children ($M$ = 11.0%, $SD$ = 13.8%, range = 0%–100%), work at home ($M$ = 9.7%, SD = 14.7%, range = 0%–90.9%), tension with a coworker ($M$ = 8.8%, $SD$ = 3.3%, range = 0%–33.33%), tension with spouse ($M$ = 4.5%, $SD$ = 9.5%, range = 0%–87.5%), and something else ($M$ = 3.8%, $SD$ = 11.3%, range = 0%–100%) at any given prompt. Based on responses to the individual parenting EMA items, when children asked to watch TV/videos or play video games, mothers or fathers allowed it an average of 89.5% ($SD$ = 19.1%) of the time. When children watched TV/videos or played video games, mothers limited it an average of 33.3% ($SD$ = 27.6%) of the time. These findings are similar to other studies reporting that 69%–81% of parents are likely to allow children to watch TV while the parent is doing chores or meal preparation [35], and that 36% of children indicate that a parent limits their TV time [36]. Also, when children asked to eat unhealthy foods, mothers or fathers allowed it an average of 84.2% ($SD$ = 26.7%) of the time. When children ate unhealthy foods, mothers limited it an average of 35.7% ($SD$ = 30.6%) of the time. Similar studies report that 16%–21% of parents do not think that it is important to restrict junk food or fast food in their child's diet [37], and that 54% of mothers of normal-weight adolescents limit their child's consumption of high-fat foods [38]. On average, mothers reported that they had encouraged their child to be physically active in 46.1% ($SD$ = 27.8%) of EMA surveys, and they had taken their child to a place to be physically active in 31.8% ($SD$ = 25.0%) of EMA surveys. Furthermore, on average, mothers reported that they had encouraged their child to eat fresh fruits or vegetables in 56.7% ($SD$ = 28.4%) of EMA prompts, and they had cooked or prepared fresh fruits or vegetables in 43.8% ($SD$ = 29.3%) of EMA prompts. Descriptive statistics for total maternal stress and weight-related parenting practices variables reported through EMA and aggregated across waves 1 and 2 are reported in Supplementary Table.

### Covariate Testing

Univariate multilevel modeling was used to identify covariates to be adjusted for in multiple multilevel regression analyses. Mothers reported less physical activity parenting (coef. = −.017, $SE$ = .033, $p$ = .601), less sedentary screen parenting (coef. = −.032, $SE$ = .017, $p$ = .062), less healthy eating parenting (coef. = −.056, $SE$ = .034, $p$ = .102), and less unhealthy eating parenting (coef. = −.046, $SE$ = .027, $p$ = .085) at wave 2 when compared with wave 1. Mothers reported more physical activity parenting in the afternoon and evening (coef. = .086, $SE$ = .027, $p$ = .0014) when compared with the morning. Mothers also reported more healthy eating parenting in the afternoon and evening (coef. = .065, $SE$ = 0.15, $p$ < .001) when compared with the morning. Mothers reported less sedentary screen parenting on the weekend days when compared with weekdays (coef. = −.45, $SE$ = .23, $p$ = .047). Mothers of families with a larger number of children reported more physical activity parenting (coef. = .45, $SE$ = .17, $p$ = .009) and healthy eating parenting (coef. = .37, $SE$ = .17, $p$ = .026). College-educated mothers reported less physical activity parenting (coef. = −1.16, $SE$ = .36, $p$ = .001). Compared with mothers of girls, mothers of boys reported more sedentary screen parenting (coef. = .71, $SE$ = .31, $p$ = .021). Unhealthy eating parenting was more frequently reported by mothers with a lower BMI (coef. = .42, $SE$ = .12, $p$ = .04) and by mothers whose children spent more afterschool time with grandparents (coef. = .74, $SE$ = .36, $p$ = .040). Therefore, these covariates were subsequently included in the multivariate statistical models. Intercorrelations between covariates included in the same statistical model ranged from r's = −.01 to −.07. Therefore, multilcolinearity among the covariates was not a problem.

### Within-Subject Effects of Maternal Stress on Subsequent Weight-Related Parenting Practices

Tables 2 and 3 show the results of multiple multilevel linear regression models testing the within-subject effects of maternal stress on subsequent weight-related parenting practices. These models predict the extent to which mothers engage in parenting practices reported at any given EMA prompt as a function of total maternal stress reported at the previous EMA prompt occurring approximately 2 hr earlier. After controlling for relevant covariates, results indicated that when mothers reported more stress than usual, they subsequently engaged in fewer physical activity parenting practices (i.e., encouraging child to be physically active, taking child places to be physically active) over the next 2 hr (WS coef. = −.12, $SE$ = .06, $p$ = .030; Table 2). In contrast, when mothers reported more stress than usual, they subsequently engaged in more parenting practices that limit sedentary screen time (e.g., not allowing or limiting) in the next 2 hr (WS coef. = .13, $SE$ = .05, $p$ = .011) after controlling

**Table 2** Results of multilevel models predicting mothers' physical activity and sedentary screen time parenting practices as a function of total maternal stress at previous ecological momentary assessment (EMA) prompt aggregated across waves 1 and 2

| | Physical activity parenting practices | | | Sedentary screen time parenting practices | |
|---|---|---|---|---|---|
| | *N* | | | *N* | |
| Level-1 *n* (Prompts) | 1,603 | | | 1,116 | |
| Level-2 *N* (People) | 187 | | | 182 | |
| | β *(SE)* | *p* | | β *(SE)* | *p* |
| Intercept | 3.82 (0.83) | <.001 | Intercept | 2.19 (0.52) | <.001 |
| Wave[a] | −0.19 (0.21) | .369 | Wave[a] | −0.41 (0.20) | .038 |
| Morning[b] | −0.02 (0.13) | .883 | Weekend day[e] | −0.30 (0.20) | .126 |
| College educated[c] | −0.76 (0.35) | .028 | Child boy[f] | 0.81 (0.27) | .003 |
| Number of children[d] | 0.54 (0.17) | .001 | – | | |
| WS total maternal stress | −0.12 (0.06) | .030 | WS total maternal stress | 0.13 (0.05) | .011 |
| BS total maternal stress | −0.03 (0.13) | .834 | BS total maternal stress | −0.23 (0.10) | .732 |

*BS* Between-subjects (centered on the group mean); *WS* Within-subjects (centered on the person mean).

Parenting practices response scale ranges from 0 to 10.

The total maternal stress variable was calculated by taking the sum of the standardized values for feeling stressed, perceived, stress, and number of stressors.

[a]Assessment wave in study (1 = wave 1 and 2 = wave 2).

[b]Time of day of the EMA survey (reference group is morning).

[c]Mother education level (reference group is not college educated).

[d]Number of children in the family.

[e]Day of the week (reference is weekday).

[f]Child sex (reference is girl).

**Table 3** Results of multilevel models predicting mothers' healthy and unhealthy eating parenting practices as a function of total maternal stress at previous ecological momentary assessment (EMA) prompt aggregated across waves 1 and 2

| | Healthy eating parenting practices | | | Unhealthy eating parenting practices | |
|---|---|---|---|---|---|
| | *N* | | | *N* | |
| Level-1 *n* (Prompts) | 1,695 | | | 540 | |
| Level-2 *N* (People) | 193 | | | 151 | |
| | β (*SE*) | *p* | | β (*SE*) | *p* |
| Intercept | 3.61 (0.59) | <.001 | Intercept | 3.55 (0.95) | <.001 |
| Wave[a] | −0.27 (0.21) | .193 | Wave[a] | −0.60 (0.31) | .052 |
| Morning[b] | 0.43 (0.13) | .001 | Afternoon grandparent[c] | 0.59 (0.36) | .107 |
| Number of children | 0.34 (0.17) | .037 | Mother underweight[d] | −0.06 (0.21) | .757 |
| WS total maternal stress | 0.11 (0.06) | .053 | WS total maternal stress | 0.01 (0.08) | .868 |
| BS total maternal stress | −0.12 (0.13) | .365 | BS total maternal stress | −0.24 (0.14) | .089 |

*BS* Between-subjects (centered on the group mean); *WS* Within-subjects (centered on the person mean). Parenting practices response scale ranges from 0 to 10.

The total maternal stress variable was calculated by taking the sum of the standardized values for feeling stressed, perceived, stress, and number of stressors.

[a]Assessment wave in study (1 = wave 1 and 2 = wave 2).

[b]Time of day of the EMA survey (reference group is morning).

[c]Child spends majority of days of the week after school with grandparent (reference group is children without grandparent childcare).

[d]Mother has a body mass index (BMI) classified as underweight (reference group is overweight/obese).

for relevant covariates (Table 2). Although not statistically significant, a similar trend was observed for healthy eating parenting practices (i.e., encouraging child to eat fresh fruits or vegetables, preparing any fresh fruits or vegetables for your child to eat). When mothers reported more stress than usual, they subsequently engaged in more healthy eating parenting practices (WS coef. = .11, *SE* = .06, *p* = .053; Table 3). Results indicated that maternal stress was unrelated to subsequent unhealthy eating parenting practices (i.e., not allowing or limiting chips, fries, pastries, sweets, or candy) in the next 2 hr (Table 3).

To further examine potential mechanisms underlying these observed effects of total maternal stress on weight-related parenting practices, exploratory analyses were conducted, which examined the effects of each type of stressor (e.g., work at home, work at a job, tension with a spouse, and tension with your children) in a series of separate models. These results indicated that higher levels of stress than usual from work at home, work at a job, tension with a coworker, and tension with one's spouse were unrelated to subsequent weight-related parenting practices in the next 2 hr. However, these post hoc analyses did show that when mothers reported higher stress than usual from demands made by family, they subsequently engaged in more healthy eating parenting practices (WS coef. = .64, *SE* = .31, *p* = .041). Post hoc analyses further revealed that when mothers reported more stress than usual from tension with children, they subsequently engaged in fewer physical activity parenting practices (WS coef. = −.71, *SE* = .34, *p* = .038) and more healthy eating parenting practices (WS coef. = .73, *SE* = .34, *p* = .030). After adjusting for multiple comparisons using the Holm–Bonferroni method, these findings were no longer statistically significant.

Results from the analyses testing the bidirectional effects indicated that when mothers engaged in more physical activity parenting than usual, they subsequently reported less stress across the next 2 hr (WS coef. = −.15, *SE* = .07, *p* = .023) after controlling for mothers' education level and number of children. The associations of sedentary screen parenting, and healthy and unhealthy eating parenting with subsequent maternal stress were not significant (*p*'s > .05).

## Discussion

The current study is one of the first known endeavors to use EMA to examine microtemporal, within-day effects of maternal stress on subsequent weight-related parenting practices. Results indicated that as expected, when mothers reported experiencing greater stress than usual, they subsequently engaged in less physical activity parenting (e.g., encouraging physical activity, taking children to a place to be physically active) over the next 2 hr. However, findings for sedentary screen parenting were contrary to hypotheses. When mothers reported experiencing greater stress than usual, they subsequently engaged in more sedentary screen behavior parenting (e.g., not allowing and limiting) over the next 2 hr. These results underscore the value of examining within-day covariations between maternal stress and weight-related parenting practices because these processes may not always unfold in the same way when studied at the between-person level as in previous work [12].

Results showed an inverse within-day association between maternal stress and subsequent physical activity parenting practices. A recent literature review on the topic found fairly consistent evidence across several studies for the association of greater maternal stress with children's lower physical activity [39]. However, studies attempting to uncover the parenting mechanisms underlying the linkages between parental stress and lower levels of children's physical activity are somewhat scant. Ego depletion theories suggest that self-control is a limited resource that determines capacity for effortful regulation of behavior [40]. Elevated levels of stress experienced by parents (such as from tension with children) may deplete self-control necessary to expend the physical, emotional, and cognitive effort to motivate, encourage, or facilitate children's physical activity behaviors. The finding that engaging in physical activity parenting practices was also associated with lower maternal stress in the next 2 hr suggests that this association may be bidirectional. Mothers may feel either proud or relieved to have successfully encouraged their children's physical activity behaviors, or taken them to a sports practice or activity class, which could reduce feelings of stress. Overall, an important contribution from this study is the evidence that these processes may unfold on a time scale as short as a few hours.

The finding, that mothers performed more limiting of sedentary screen behaviors when they were feeling more stressed, runs contrary to what was expected. This finding also diverges from the O'Connor and colleagues review [39], which found consistent evidence for the association between greater maternal stress and greater sedentary behavior performed by children. Several explanations could account for these positive relationships between maternal stress and subsequent sedentary screen parenting at the microtemporal level. First, mothers may experience stress in anticipation of upcoming parenting (i.e., the need to limiting screen time), perhaps due to expected demands exceeding one's forecasted resources or prior negative experiences with these types of parenting practices. Second, weight-related parenting practices such as limiting screen time and encouraging healthy eating may trigger negative interpersonal interactions with children, which could be sources of stress for mothers. However, analyses examining the bidirectional effect of sedentary screen parenting on subsequent

maternal stress measured 2 hr later were not statistically significant. Lastly, the need to limit children's screen time may occur at the same times of the day as other stressful parenting and family activities such as taking children to after-school lessons, facilitating homework, and bathing and bedtime routines. In contrast to encouraging physical activity, limiting sedentary screen time may require less effort, be less vulnerable to ego depletion, and be more highly integrated into these after school and evening routines. Thus, the observed association between higher levels of maternal stress and greater participation in parenting in the areas of limiting screen time may be confounded by other unmeasured co-occurring stressful events. Future studies could use EMA to examine how other parenting activities such as homework assistance or sleep preparation could support or undermine weight-related parenting practices.

Also, contrary to hypotheses, maternal stress was unrelated to subsequent unhealthy eating parenting (e.g., not allowing or limiting children's consumption of chips, fries, pastries, sweets, or candy). These results are consistent with the review paper by O'Connor and colleagues [39], which did not find any evidence for the association of maternal stress with children's healthy or unhealthy dietary intake. It is relevant to note, however, that the positive association between increased maternal stress and greater subsequent healthy eating parenting approached statistical significance. The follow-up analyses examining the effects of specific types of maternal stressors further support the notion that mothers' attempts to encourage healthy eating in children may occur at the same times of the day as other stressful parenting and family activities or be a co-occurring source of stress itself. The association between increased maternal stress and greater healthy eating parenting was mainly driven by increased stress from tension with children and demands by family. However, these follow-up analyses should be interpreted with caution because the results were no longer statistically significant after adjusting for multiple comparisons. The bidirectional effect of healthy eating parenting on subsequent maternal stress was not statistically significant, suggesting that encouraging children to eat healthy foods and preparing healthy foods does not seem to have a lingering effect on stress levels 2 hr later.

### Limitations

Despite the strengths of the study including the collection of intensive longitudinal data using real-time report measures, there were a few limitations. The use of short stress measures consisting of only a few items is not preferable, yet it is often necessary in EMA research to keep electronic surveys reasonably short to limit potential participant burden. Also, the extent to which mothers felt compelled to give socially desirable responses pertaining to weight-related parenting is unknown given that existing EMA measures of weight-related parenting were not available, and these measures were developed specifically for the current study. Social desirability was minimized by collection of data in a confidential manner and outside the context of an intervention. A further potential limitation is that the study did not specifically assess the latent effects of stress occurring at earlier periods of the day. Thus, the ability to differentiate stress that has spilled over from these periods from stress encountered during mother-child interactions is limited. However, the lack of association between work-related stress and subsequent weight-related parenting suggests that there may not have been extensive work-to-home stress spill-over. Additionally, the 2 hr intervals used to assess temporal directionality of effects between stress and parenting may not capture acute WS effects that play out over shorter time frames (e.g., maternal stress influencing parenting over the next 30 min or parenting influencing stress over the next hour). Future studies on within-day effects of stress on weight-related parenting may explore other time intervals. Lastly, mothers enrolled in the study were largely married, working outside the home, well-educated, and had elementary school-age children. Results may not generalize to single mothers, mothers who stay at home with their children, or mothers who have not graduated from college. Results also may not apply to father-child dyads, or to preschoolers or adolescents.

## Conclusions

Findings suggest that addressing the issue of maternal stress may be a necessary component of successful parent-focused child obesity prevention interventions. Strategies may be developed to boost coping skills or help mothers seek out sources of support to reduce stress at critical times of the day when physical activity parenting is needed. Also, interventions could emphasize that engaging in physical activity parenting itself could be a way to reduce stress. Although the directionality of the associations may still require further temporal resolution, the fact that higher stress positively covaries with more sedentary screen parenting and more healthy eating parenting on a within-day time scale suggests that these parenting behaviors are performed during or close in time to stressful periods of the day for mothers. Interventions may benefit from acknowledging that limiting children's screen time and preparing healthy meals may contribute to or result from negative family interactions and stressful parenting situations, and from seeking creative solutions to uncouple stress and these weight-related parenting practices.

## Supplementary Material

Supplementary material is available at *Annals of Behavioral Medicine* online.

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### Compliance with Ethical Standards

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### Authors' Contributions

**Ethical Approval** All procedures performed in studies involving human participants were in accordance with the ethical standards of the Institutional Review Boards at the University of Southern California and Northeastern University and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

**Informed Consent** Informed consent was obtained from all individual participants included in the study.

**Author Contributions** G.F.D formulated the research questions; G.F.D designed the study; W.K. and E.D. processed and cleaned the data; W.K. analyzed the data, G.F.D. wrote the article; W.K., E.D., S.G.C., N.V.L., and G.M. reviewed and edited the article.

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