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Interactive effects of parenting behavior and regulatory skills in toddlerhood on child weight outcomes

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Abstract

Objectives—There is limited research investigating whether maternal behaviors exhibited during non-feeding contexts play a role in the development of obesity, and whether this association varies based on children's emerging regulatory skills. The objective of this study was to investigate interactions between maternal behaviors and toddler regulation predicting child BMI z-scores (BMIZ) at 4.5 years.

Subjects/Methods—Infant–mother dyads (*n* = 108) participated in laboratory visits when the child was 18 months and 4.5 years of age. Maternal interactive behaviors (i.e., positive responsiveness, gentle control) were coded from recordings of free play and clean-up tasks with their toddlers. Toddler regulation was assessed via an observational task, experimenter ratings, and parent ratings. Child and mother length/height and weight measurements were recorded and used to calculate child BMIZ and maternal BMI, respectively.

Results—After controlling for covariates, two significant interactions emerged between maternal behaviors and toddler regulation predicting BMIZ at 4.5 years. First, an interaction of positive responsiveness during free play and toddler regulation demonstrated that greater positive responsiveness significantly related to lower child BMIZ for toddlers with poor regulation. Second, an interaction of gentle control during clean-up and toddler regulation indicated that greater gentle control was associated with lower BMIZ for toddlers with lesser regulatory abilities, but higher BMIZ for well-regulated toddlers. No significant main effects emerged for maternal interactive behaviors or toddler regulation.

Conclusions—These results suggest that associations between maternal behaviors and child BMIZ may depend on toddlers' emerging regulatory abilities. Maternal responsiveness during free play and gentle control during clean-up appear to protect against weight gain, especially for toddlers with lower regulatory abilities. However, greater levels of gentle control may have adverse effects on BMIZ for well-regulated toddlers. These results suggest that both parenting and

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toddler regulation, examined outside feeding contexts, may have important implications for child obesity.

Recent estimates of pediatric obesity indicate that by middle childhood, 17.5% of children in the United States are classified as obese, with 5.6% of those children being classified as extremely obese [1]. Due to the high prevalence of pediatric obesity, its links to adult obesity [2], and its persistent adverse health and psychosocial outcomes [3, 4], it is critical to identify factors in early childhood that contribute to obesity risk.

One potential risk factor for childhood obesity is a low capacity for self-regulation, which includes the conscious or unconscious ability to control or modulate behaviors, emotions, and cognitions across situations [5, 6]. Many studies have demonstrated links between regulation and obesity in middle and late childhood [7, 8], but few studies have examined these associations in toddlerhood. Yet, toddlerhood is a critical period in which to explore such links since it is characterized by the rapid development of and individual differences in regulatory capacity [5, 9]. Indeed, two studies demonstrated that components of self-regulation, specifically poor emotion regulation and inhibitory control [i.e., the ability to refrain from a dominant response; see ref. 10], at age two years were associated with subsequent classifications of overweight/at-risk at 5.5 and 10 years [11, 12]. Another study demonstrated that poor behavioral self-regulation in a food-related task and poor emotion regulation (i.e., more negative affect) during food and non-food frustration tasks were associated with greater concurrent odds of overweight/obesity during toddlerhood [13]. Taken together, these results provide preliminary evidence that toddler self-regulation, measured within and beyond food contexts, may have important implications for child weight status.

Parent–child interactions play an important role in the development of regulation, especially during toddlerhood when children are learning to align their behavior and emotions with simple social requests [5, 9]. For example, parent–child interactions characterized by high levels of positive affect, mutual compliance, and/or synchrony during toddlerhood have been associated with positive child regulatory outcomes, such as high levels of self-control or compliance [14, 15]. Maternal gentle control or structure has also related to greater child compliance [15]. Recent work has also revealed that maternal interactive behaviors may be particularly beneficial in the development of self-regulation for certain children. For example, in toddlers classified as temperamentally exuberant, who are thought to be at risk for regulatory difficulties due to their high approach behavior, mothers' gentle control in both a free play and clean-up context related to better later behavioral self-regulation [16].

Parent–child interactions have also been associated with childhood obesity [see ref. 17 for a review]. However, these interactions are commonly assessed during feeding and there is limited research investigating whether maternal behaviors displayed in other contexts also play a role in the development of obesity [18]. Existing studies on this topic have revealed conflicting results. Some studies have demonstrated links between poor interactional quality (i.e., low sensitivity, low parental warmth) [19–21] and an increased risk for obesity, whereas other studies have found no associations [22]. Additional research may help clarify why such mixed results have emerged. For example, it is possible that previously unmeasured third variables, such as child self-regulation, may play an important role in the association between general parenting behaviors and child weight status.

In sum, prior research has established links between maternal interactive behaviors and the development of child regulatory abilities, and additional research has linked child self-regulation to obesity. However, there is limited and conflicting research investigating whether maternal behaviors in non-feeding contexts also play a role in the development of obesity, and whether this association varies based on children's regulation. The purpose of the present study was to investigate interactions between toddler regulatory abilities and maternal interactive behaviors (i.e., positive responsiveness, gentle control) predicting child weight at 4.5 years. Toward this end, we obtained ratings and observations of toddler regulation, observed maternal interactive behavior in two contexts (i.e., free play, clean-up), and measured child weight and height at 4.5 years. Based on prior research, we hypothesized that poor regulatory abilities at 18 months would be associated with greater child BMI z-scores (BMIZ) at 4.5 years. Furthermore, we hypothesized that maternal positive responsiveness and gentle control in each context would protect against greater child BMIZ, especially for toddlers with poorer regulatory abilities.

Method

Participants

Primary caregivers and their infants (N = 160; 75 female infants) participated in a longitudinal study with laboratory visits occurring when the infants were within two weeks of being 6, 12, and 18 months of age. A subset of the sample participated in a follow-up study when the children were 4.5 years of age (n = 114; M = 4.56 years). In all but one family, the mother served as the primary caregiver; thus, primary caregivers are hereafter referred to as "mothers." Families were primarily non-Hispanic white (n = 150) and mothers averaged 29.66 years of age at their child's birth and at least 2 years of education beyond high school. The majority of mothers were married upon study entry (n = 131). All study procedures were approved by The Pennsylvania State University Human Subjects Institutional Review Board and written consent was obtained from parents for their own and their children's participation in the study.

Dyads who participated in both the 18 month and 4.5 year laboratory visits with complete observational and parent report data were included in the present study (n = 105). A total of 23 families who participated at 18 months did not participate at 4.5 years due to reasons such as family relocation and inability to contact families. There were no systematic differences between participants who completed the 4.5 year visit and those who dropped out of the study on demographic variables (i.e., maternal education, family income).

Procedure

At study entry, mothers reported demographic information, including education and family income, and an experimenter measured the mother's height and weight. Prior to each subsequent laboratory visit, mothers completed a number of questionnaires.

During the 18-month visit, mothers and toddlers participated in a variety of tasks designed to elicit toddler temperament and regulatory abilities. Relevant to the present study, toddlers participated in an inhibitory control task with an experimenter, as well as a free play and clean-up task with their mothers. For the inhibitory control task, an experimenter instructed the toddler not to touch an attractive wind-up toy during three separate trials of increasing duration (5s, 10s, 15s). Each trial ended when the child touched the toy or after the intended trial duration. For the free play task, mothers were asked to play with their toddlers and a basket of age-appropriate toys as they normally would at home. After 5 minutes, an experimenter signaled to the mother to initiate the clean-up task by prompting her toddler to return as many toys to the basket as possible, independently. The task ended when the toddler returned all toys or when 3 minutes elapsed.

At the end of each study visit, an experimenter measured the child's weight and length/ height measurements and the mother's weight measurements in triplicate. Finally, two research assistants rated the toddler's behavior across the visit.

Measures

Anthropometrics—Toddlers' measurements from the 18-month visit were used to calculate weight-for-length z-scores (WFLZ) using the WHO growth standards. Children's height and weight measurements at 4.5 years were used to calculate child BMI z-scores (BMIZ) and percentiles using the CDC growth standards. Additionally, maternal BMI was calculated using the 4.5-year weight measurements and the height measurements taken during the first study visit. Three mothers were pregnant during the 4.5-year visit, so their BMI scores were calculated using their weight measurements at 18 months. Two mothers who were pregnant during both visits were dropped from analyses due to the inability to collect accurate weight measurements.

Toddler regulation

Behavioral observation—Trained research assistants coded the toddlers' latencies to reach for the toy during the inhibitory control task. In cases where the toddler waited the full time without reaching (Trial 1: 45.7% of toddlers; Trial 2: 41.0%; Trial 3: 41.9%), they received a score equivalent to the duration of the trial (i.e., 5s, 10s, 15s). Descriptive statistics for each trial are displayed in Table 1. Drift reliability was assessed on 21% of recordings, with an ICC = .996. Latency scores were standardized and averaged to create one observed inhibitory control score for each toddler.

Experimenter ratings—After the 18-month visit, two experimenters independently rated each toddler's temperament using the Infant Behavior Record (IBR) [23]. Of the 12 items, 3 items measuring components of toddler regulation were examined in the present study: attention span (continued interest in persons, tasks, or activities), object orientation (sustained interest in lab materials), and compliance (willingness to complete requests from the experimenter or mother). Each item was scored on a 9-point scale with anchors specific to the item. Ratings from the two experimenters were highly correlated on the items of interest ($r = .70$, $p < .001$), so they were averaged. Furthermore, all 3 items were correlated (r's > .28, p's < .05) and averaged to create one rating of regulation for each toddler with higher scores indicating better regulation (α = .73). Descriptive statistics for the IBR regulation composite and subscales are displayed in Table 1.

Parent ratings—Prior to the 18-month visit, mothers completed the Early Childhood Behavior Questionnaire (ECBQ) as an assessment of toddler temperament [24]. Mothers rated their toddler's behavior in the past two weeks on 201 items using a 7-point Likert scale ranging from 1 (never) to 7 (always). The items can be combined into subscales, and further combined into broad temperament superfactors. Of interest in the present study was the effortful control superfactor, which is a measure of regulation comprised of the following subscales: inhibitory control (12 items), attention shifting (12 items), low-intensity pleasure (11 items), cuddliness (12 items), and attention focusing (12 items). This superfactor demonstrated adequate internal consistency in the present study (α = .67). Descriptive statistics for the effortful control superfactor and subscales are displayed in Table 1.

Regulation composite—To create a final regulation composite for each toddler, z-scores for observed inhibitory control, experimenter-rated regulation, and parent-rated effortful control were averaged. Observations and experimenter ratings were significantly correlated ($r = .24$, $p = .016$) and there was a trend toward significance for the observations and parent ratings ($r = .16$, $p = .095$). Experimenter and parent ratings were not significantly correlated ($p = .95$); however, such disagreement is common in the literature [23, 25]. Higher scores on the final regulation composite indicate better regulation demonstrated across contexts and tasks, and as reported by multiple raters.

Maternal interactive behaviors—To capture maternal interactive behaviors in contexts with and without regulatory demands, maternal behaviors were coded during both the free play and clean-up tasks [16].

Positive responsiveness—Maternal positive responsiveness scores were created from two separate coding schemes assessing responsiveness and affect. The maternal responsiveness scheme was adapted from prior research [26, 27] and codes captured a willingness to endorse the child's choices, follow the child's agenda, and/or provide reasoning about behavior to the child. Presence or absence of responsive behaviors was coded in 10-second intervals. Behaviors were not mutually exclusive, so multiple behavior types could be coded per interval; a "none" code was assigned otherwise. Drift reliability was assessed on 21% of recordings with all kappas > 0.75 for both tasks. Responsiveness scores were calculated as the proportion of total behaviors (i.e., the total number of responsive codes and "none" codes) that were coded as responsive.

Maternal affect was coded in 10-second intervals using a coding scheme adapted from previous research [15][14]. Trained coders assigned codes on a 3-point scale with levels of 0 (negative; some indication of negativity, irritation, impatience, or boredom), 1 (neutral/ positive; no negative or clear positive affect but the interaction is neutral or pleasant), and 2 (high positive; a clear smile, positive vocalization (laugh), or playful or joyful intonation). No mothers displayed negative affect beyond a mild level. Drift reliabilities were assessed on 21% of recordings, with ICC = .80 for free play and ICC = .80 for clean-up. Maternal affect scores were calculated separately for each task as the mean level of affect across intervals.

Maternal affect and responsiveness were significantly correlated in the free play ($r = .37$, $p < .001$), but not the clean-up task ($r = .10$, $p = .314$). This is likely because mothers tended to be responsive to a more specific type of toddler behavior during the clean-up (i.e., compliance in putting the toys away) relative to the free play task. Positive responsiveness scores were created for each mother by standardizing and averaging responsiveness and affect scores for the free play and clean-up tasks separately.

Gentle control—The maternal gentle control scheme was also adapted from past research [26, 28] and codes captured attempts to change, redirect, or elicit child behavior or attention, as long as they were displayed with positive or neutral affect. Coders also observed negative or power-assertive control, but these behaviors were displayed infrequently by a few mothers and were not considered further. Presence or absence of behaviors was coded in 10-second intervals. Behaviors were not mutually exclusive, so multiple behavior types could be coded per interval; a "none" code was assigned otherwise. Drift reliability was assessed on 21% of recordings with all kappas > .84 for both tasks. Gentle control scores were calculated as the proportion of total behaviors (i.e., the total number of control codes and "none" codes) that were coded as gentle control.

Toddler responsiveness—Since it is likely that the children's behaviors during the tasks would influence maternal behaviors during the same task, presence or absence of toddler responsive behavior was coded in 10-second intervals. This was defined as a shift in behavior or attention to align with the mothers' behaviors or requests. During the free play this included behaviors such as taking a toy offered by the mother or producing a play behavior (e.g., beating on a drum) at the mother's encouragement. In the clean-up, mother's requests were almost exclusively tied to the clean-up task, so responsive behavior reflected clean-up behavior defined as putting toys into the basket. Drift reliability was assessed on 21% of recordings with an ICC = .78 for free play and ICC = .93 for clean-up. Both behavior scores were calculated as the proportion of total intervals in which the behavior was coded.

Toddler receptive language—Due to possible differences in understanding of verbal requests during the inhibitory control and play tasks, toddler receptive vocabulary was assessed using the Bayley Scales of Infant and Toddler Development [29]. Scaled receptive vocabulary scores were created for each toddler ($M = 10.40$, $SD = 3.17$).

Covariates—Maternal education and BMI were controlled in analyses predicting child BMIZ due to relevant associations in the literature [30, 31]. To control for weight status when the predictor variables were measured, child WFLZ at 18 months were also included. Additionally, toddler responsive behaviors and receptive vocabulary scores were entered as covariates in all analyses for reasons described above.

Analytic Plan

Descriptive statistics and inter-correlations were conducted for all primary study variables. To determine the prevalence of childhood overweight/obesity in this sample, the frequency of children classified as overweight or obese (>85^{th} percentile) at 4.5 years of age was calculated using BMI percentiles.

Multiple regression analyses were conducted to test study hypotheses. Covariates (maternal education, maternal BMI, toddler WFZ, toddler responsive behavior, receptive vocabulary), toddler regulation, maternal interactive behaviors, and statistical interactions (toddler regulation × maternal behaviors), were entered as predictors of child BMIZ at 4.5 years. A total of four models were conducted with separate models for each context (i.e., free play, clean-up) and maternal behavior (i.e., positive responsiveness, gentle control). Significant interactions were probed by testing the simple slope of maternal behaviors one standard deviation above and below the mean on toddler regulation. Analyses were repeated with the removal of non-significant covariates; since all findings were similar, the models adjusted for demographics are reported herein. Analyses were conducted using SPSS Statistics 24 and SAS version 9.4 and a significance level of $p < .05$ was retained.

Results

Descriptive statistics for all study variables can be found in Table 2 and correlations between the variables can be found in Table 3. Based on the CDC definitions, 25.9% of children in this sample were classified as overweight or obese at 4.5 years of age, which is slightly above the national average in the United States for children between the ages of two and five years [32]. As expected, WFLZ at 18 months were significantly correlated with child BMIZ at 4.5 years ($r = .70$, $p < .001$). Toddler regulation was significantly correlated with maternal positive responsiveness during both the free play ($r = .20$, $p = .040$) and clean-up tasks ($r = .21$, $p = .028$). Conversely, toddler regulation was unrelated to maternal gentle control.

Positive responsiveness

As displayed in Table 4, both regression models predicting child BMIZ at 4.5 years from toddler regulation, maternal positive responsiveness, and their interaction were significant (p's <.001). In model 1 (free play), the main effects for toddler regulation and positive responsiveness were non-significant. However, a significant interaction emerged between toddler regulation and positive responsiveness (See Figure 1). Follow-up tests revealed that for toddlers with poorer regulatory abilities, higher levels of maternal positive responsiveness related to lower child BMIZ at 4.5 years ($B = -0.42$, $t = -2.76$, $p = .007$). The simple effect of maternal positive responsiveness was non-significant for toddlers with better regulatory abilities.

In model 2 (clean-up), the significance of the model was accounted for by child WFLZ at 18 months. No significant effects emerged for toddler regulation, positive responsiveness, or their interaction.

Gentle control

Both regression models predicting child BMIZ at 4.5 years from toddler regulation, maternal gentle control, and their interaction were significant (p's <.001). In model 3 (free play), the significance of the model was accounted for by child WFLZ at 18 months of age. No significant effects emerged for toddler regulation, gentle control, or their interaction.

In model 4 (clean-up), the main effects for toddler regulation and gentle control were non-significant. However, a significant interaction emerged between toddler regulation and gentle control (See Figure 2). Follow-up tests revealed that for toddlers with poorer regulatory abilities, greater gentle control related to lower child BMIZ at 4.5 years of age ($B = -2.11$, $t = -2.19$, $p = .031$). Conversely, for toddlers with better regulatory abilities, greater gentle control during clean-up related to higher child BMIZ at 4.5 years ($B = 1.49$, $t = 2.18$, $p = .032$).

Discussion

The goal of the present study was to examine interactions between toddler regulation and maternal interactive behaviors predicting child BMIZ at 4.5 years of age. Based on prior research, we hypothesized that poorer regulatory abilities during toddlerhood would be associated with greater BMIZ at 4.5 years. We further hypothesized that maternal positive responsiveness and gentle control would play a protective role in the development of obesity, especially for toddlers with poorer regulatory abilities. Overall, our results are largely consistent with our hypotheses.

In the present study, toddler regulation moderated the associations between maternal behaviors and child BMIZ. In particular, both positive responsiveness during free play and gentle control during clean-up were associated with lower BMIZ at 4.5 years for toddlers with lesser regulatory abilities at 18 months. These results are consistent with previous research demonstrating that parent–child interactions filled with positive affect and/or responsiveness provide a positive socialization environment for the child to learn to accept the parent's agenda [33]. These concepts are particularly important in the development of child regulatory abilities since regulation requires alignment of behaviors and emotions with social requests [5, 9]. Our results contribute to the existing research by demonstrating that parent–child interactions with high levels of positive affect and responsiveness may also protect against obesity risk. Specifically, these interactions appear to be impactful for less-regulated toddlers when displayed in a free play context, while regulatory structure is less salient and opportunities to forge mutual responsiveness may be heightened.

Maternal gentle control also emerged as a protective factor for toddlers with lesser regulatory abilities when mothers exhibited these behaviors in a clean-up context. Unlike free play, the structured clean-up task involves a regulatory goal for the toddlers: they must inhibit the desire to play with the toys in order to engage in the undesired behavior of putting the toys away [28]. Toddlers who are less regulated struggle to comply with requests during this task, but they appear to benefit from additional gentle control or structure from the mother. Such maternal behaviors may allow these toddlers to practice their regulatory skills and build competence toward the ability to regulate independently, as well as protect against obesity risk in the long term.

Conversely, gentle control was associated with greater child BMIZ for toddlers with better regulatory abilities. These putatively positive behaviors were demonstrated frequently during both tasks, indicating constant intervention from the mothers. This amount of control may be somewhat intrusive for well-regulated toddlers when displayed in contexts with salient regulatory cues. Specifically, constant gentle control without allowing time for the child to produce the requested behaviors may disrupt the child’s ability to practice regulatory skills in the moment. Furthermore, these behaviors may impede further development of regulatory qualities over time. Taken together, our results indicate that the effect of the same type and level of parenting on child outcomes, in the present case, child BMIZ, differs depending on variations in the child’s characteristics.

Contrary to hypotheses and previous studies [11–13], no direct associations emerged between toddler regulation and child weight. Possible explanations for the divergent findings include differences in measurement of self-regulation across studies and differences in study samples. First, we focused exclusively on behavioral regulation in a non-food task, whereas other studies have incorporated additional components of self-regulation, such as emotion regulation [11–13], and measured regulation in additional contexts, such as food-related tasks [13]. These components and contexts appear to have implications for later obesity and were not measured here, which possibly hampered our ability to find direct associations between self-regulation and weight. Second, previous research specifically focused on children who may be at a greater risk for obesity due to factors such as low-income [13] or a high risk of behavior problems [12]. These factors possibly contributed to the detection of direct associations in previous studies.

Our results suggest that parenting in non-feeding contexts is relevant to children’s weight outcomes. These findings are consistent with recent studies demonstrating that parent–child interactions during early childhood are associated with later obesity in childhood and adolescence [19–21]. One possible pathway through which interactions in non-feeding contexts may be linked to childhood obesity is through the child’s self-regulatory abilities [34]. Given that children’s development of appetite self-regulation and general self-regulation are highly related and each embedded within the family system [35], parent–child interaction qualities believed to encourage the development of general self-regulation may have consequences for the regulation of appetite and, in turn, children’s weight status. Future research may better address the specific mechanisms of these effects.

This study has many strengths including the longitudinal study design, the use of multiple methods to assess toddler regulation (i.e., observations, parent ratings, and observer ratings), and observations of parent behavior. Furthermore, this study examined both regulation and maternal behaviors during toddlerhood, which is a critical period for the development of both regulation and obesity risk. However, we caution that these findings may have limited generalizability beyond this well-educated, predominately non-Hispanic white sample.

Conclusions

In summary, our results demonstrated that toddler regulation moderated the association between maternal interactive behaviors and child BMIZ. In particular, differential results emerged for children depending on their regulatory abilities at 18 months. For toddlers with poorer regulatory abilities, maternal positive responsiveness during free play and gentle control during clean-up were associated with lower BMIZ at 4.5 years. However, for well-regulated toddlers, maternal gentle control during clean-up was associated with higher BMIZ during childhood. These results suggest that both toddler regulation and parenting behaviors, examined outside of feeding contexts, may have important implications for the development of obesity risk in early childhood.

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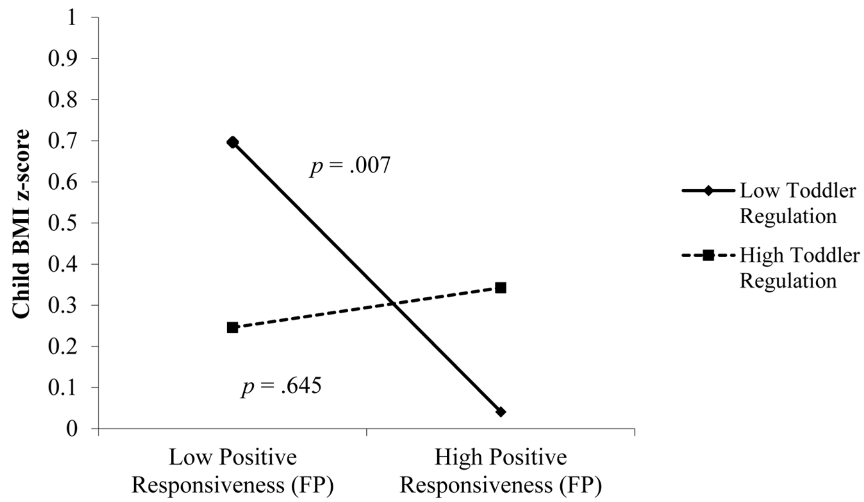

Figure 1.

Interaction between toddler regulation and maternal positive responsiveness during free play (FP) predicting child BMI z-score at 4.5 years of age.

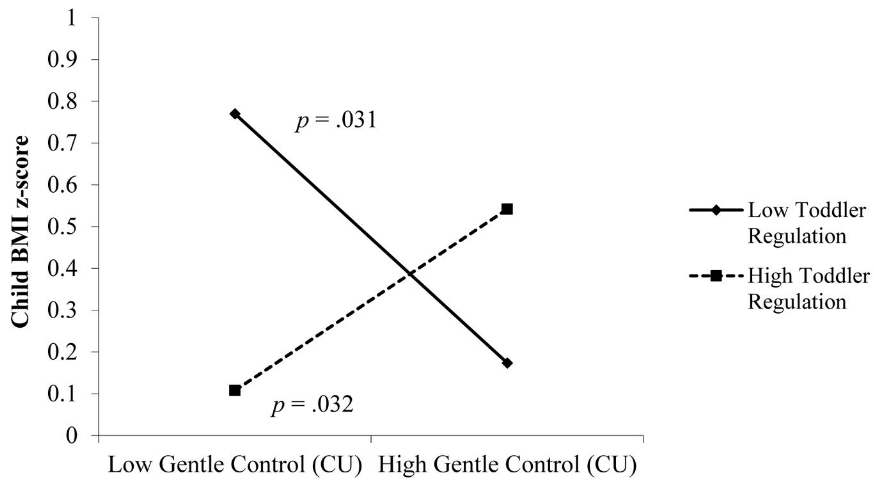

Figure 2.

Interaction between toddler regulation and maternal gentle control during clean-up (CU) predicting child BMI z-score at 4.5 years of age.

Table 1

Descriptive Statistics for Child Regulation Measures: Behavioral Observations, Experimenter Ratings, and Parent Ratings

	M	***SD***	**Min**	**Max**
Behavioral Observation:				
Trial 1 (Max 5 seconds)	3.14	1.89	0.00	5.00
Trial 2 (Max 10 seconds)	5.59	3.99	0.00	10.00
Trial 3 (Max 15 seconds)	8.07	6.50	0.00	15.00
Experimenter Ratings:				
IBR Regulation Composite	5.83	0.78	3.50	8.00
Attention Span	5.68	0.90	3.00	8.00
Object Orientation	6.22	0.86	4.00	8.50
Compliance	5.60	1.30	2.00	9.00
Parent Ratings:				
ECBQ Effortful Control	4.28	0.54	2.89	5.63
Inhibitory Control	3.58	0.93	1.67	5.67
Attention Shifting	4.30	0.65	2.83	5.91
Low-Intensity Pleasure	4.54	0.87	2.11	6.18
Cuddliness	4.84	0.85	2.25	6.25
Attention Focusing	4.12	0.82	2.27	6.08

Note. IBR = Infant Behavior Record; ECBQ = Early Childhood Behavior Questionnaire

Table 2

Descriptive Statistics for Covariates, Toddler Regulation, Maternal Behaviors, and Child BMI

	M	*SD*	Min	Max
Covariates:				
Maternal Education (years)	15.06	2.01	12.00	20.00
Maternal BMI	28.86	7.04	18.58	53.41
WFL z-score (18 months)	0.59	0.95	−1.56	2.77
Toddler Responsiveness (Free Play)^{P}	0.85	0.11	0.50	1.00
Toddler Responsiveness (Clean-Up)^{P}	0.40	0.28	0.00	1.00
Toddler Receptive Language (scaled score)	10.40	3.17	2.00	19.00
Toddler Regulation:				
Regulation Composite (18 Months)^{Z}	0.06	0.61	−1.65	1.37
Maternal Interactive Behaviors:				
Positive Responsiveness (Free Play)^{Z}	-0.02	0.81	−1.60	3.67
Positive Responsiveness (Clean-Up)^{Z}	0.06	0.75	−1.49	2.71
Gentle Control (Free Play)^{P}	0.81	0.12	0.39	1.00
Gentle Control (Clean-Up)^{P}	0.90	0.14	0.20	1.00
Child BMI:				
BMI z-score (4.5 years)	0.36	1.06	−2.70	2.91

Note.

^{P}Variable calculated as the proportion of total intervals in which the behavior was coded.

^{Z}Composite variable created by standardizing and averaging its subcomponents.

Table 3

Correlations between the Covariates, Toddler Regulation, Maternal Behaviors, and Child BMI

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1. Maternal Education	---	−.22*	.15	.24*	.09	.09	.25**	.19*	.00	−.23*	−.10	.04
2. Maternal BMI		---	.04	−.14	−.25**	−.17	−.08	−.25*	−.04	.10	.15	.14
3. WFL z-score (18 months)			---	−.10	−.06	−.04	.01	.11	.00	−.22*	−.02	.70**
4. Toddler Receptive Language				---	.26**	.24*	.41**	.09	.06	−.05	−.05	−.13
5. Toddler Responsiveness (FP)					---	.22*	.15	.16	.17	−.05	−.09	−.11
6. Toddler Responsiveness (CU)						---	.21*	.12	.53**	−.09	−.34**	−.11
7. Toddler Regulation Composite							---	.20*	.21*	−.02	.11	−.08
8. Positive Responsiveness (FP)								---	.26**	−.17	−.07	−.06
9. Positive Responsiveness (CU)									---	−.08	−.26**	−.02
10. Gentle Control (FP)										---	.35**	−.04
11. Gentle Control (CU)											---	.07
12. Child BMI z-score (4.5 years)												---

Note. FP = Free Play, CU = Clean-Up,

* $p < .05$,

** $p < .01$

Table 4

Multiple Regression Results Predicting Child BMIZ at 4.5 years from Covariates, Toddler Regulation, and Maternal Interactive Behaviors

	B	***SE*(B)**	**β**	***F***	***R*²**
I. Positive Responsiveness (FP)				14.67***	.55
Maternal Education	−.03	.04	−.06		
Maternal BMI	.01	.01	.04		
Toddler Receptive Language (18 months)	.00	.03	−.01		
WFL z-score (18 months)	.79	.08	.71***		
Toddler Responsiveness (FP)	−.45	.73	−.05		
Toddler Regulation	−.06	.13	−.03		
Positive Responsiveness (FP)	−.18	.10	−.13+		
Regulation × Pos. Responsiveness (FP)	.39	.15	.19*		
II. Positive Responsiveness (CU)				13.03***	.52
Maternal Education	−.03	.04	−.06		
Maternal BMI	.01	.01	.07		
Toddler Receptive Language (18 months)	.01	.03	.03		
WFL z-score (18 months)	.78	.08	.71***		
Toddler Responsiveness (CU)	−.38	.34	−.10		
Toddler Regulation	−.13	.15	−.07		
Positive Responsiveness (CU)	.08	.13	.06		
Regulation × Pos. Responsiveness (CU)	−.19	.21	−.07		
III. Gentle Control (FP)				13.11***	.52
Maternal Education	−.02	.04	−.04		
Maternal BMI	.01	.01	.08		
Toddler Receptive Language (18 months)	.00	.03	−.01		
WFL z-score (18 months)	.81	.08	.73***		
Toddler Responsiveness (FP)	−.13	.74	−.01		
Toddler Regulation	−.11	.14	−.06		
Gentle Control (FP)	.78	.65	.09		
Regulation × Gentle Control (FP)	.59	1.13	.04		

	B	*SE*(B)	β	*F*	R^2
IV. Gentle Control (CU)				15.18***	.56
Maternal Education	−.04	.04	−.07		
Maternal BMI	.01	.01	.07		
Toddler Receptive Language (18 months)	.01	.03	.02		
WFL z-score (18 months)	.82	.08	.74***		
Toddler Responsiveness (CU)	−.22	.29	−.06		
Toddler Regulation	−.12	.13	−.07		
Gentle Control (CU)	−.31	.58	−.04		
Regulation × Gentle Control (CU)	2.95	.99	.22**		

Note. FP = Free Play, CU = Clean-Up,

+ $p < .10$,

* $p < .05$

** $p < .01$

*** $p < .001$