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PEDIATRIC ORIGINAL ARTICLE

Predicting weight outcomes in preadolescence: the role of toddlers' self-regulation skills and the temperament dimension of pleasure

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OBJECTIVES: To investigate the role of toddlers' self-regulation skills and temperament in predicting weight outcomes in preadolescence.
METHODS: Participants for this study included 195 children (114 girls) obtained from three different cohorts participating in a larger ongoing longitudinal study. At 2 years of age, participants participated in several laboratory tasks designed to assess their self-regulation abilities, including emotion regulation, sustained attention and delay of gratification, whereas parents filled out a temperament questionnaire to assess toddlers' pleasure expression. Height and weight measures were collected when children were 4, 5, 7 and 10 years of age. Children also filled out a body image and eating questionnaire at the 10-year visit.
RESULTS: Self-regulation skills in toddlers were associated with body mass index (BMI) development and pediatric obesity as well as body image/eating concerns. The temperament dimension of pleasure was also associated with BMI development and pediatric obesity but not body image/eating concerns.
CONCLUSIONS: Self-regulation difficulties across domains as well as temperament-based pleasure in toddlers represented significant individual risk factors for the development of pediatric obesity 8 years later. Early self-regulation difficulties also contributed to body image and eating concerns that typically accompanied overweight children. The mechanisms by which early self-regulation skills and temperament-based pleasure may contribute to the development of pediatric obesity and associated weight concerns are discussed.

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Keywords: pediatric obesity; BMI; body image; self-regulation; toddlerhood; preadolescence

INTRODUCTION

Although childhood obesity rates appear to have plateaued in recent years, its prevalence is still high. Approximately 25% of US children aged 2 to 5 years are classified as overweight (body mass index (BMI) between 85th and 95th percentile for age and gender) or obese (BMI >95th percentile), with that figure increasing to over 35% among school-age children.[1,2] The health risks associated with pediatric obesity (for example, hypertension) are well established,[3,4] contributing to high annual public health costs.[5] Psychosocial factors such as body image dissatisfaction and disturbed eating attitudes are also considered etiological risk factors for obesity as well as eating disorders and depression.[6–10] The health and psychosocial costs associated with pediatric obesity along with its high stability highlight the need to identify its early predictors.[4,11]

The present study used Rothbart's model of temperament that comprises two main components: reactivity and self-regulation. Reactivity processes emerge during the newborn period and can either be positive or negative. Negative reactivity is defined by expressed and felt distress and behavioral and attentional aversion. Positive reactivity is reflected as expressed and felt positive affect and behavioral and attentional approach. Hence, the tendency to express *pleasure* is considered a temperamental dimension of positive reactivity in toddlers.[12,13] Self-regulation pertains to processes such as attention, approach, avoidance and inhibition, all of which enhance and/or inhibit reactivity.[14–16] One important dimension of self-regulation is behavioral inhibition to novel or intense stimuli (for example, reward sensitivity) where a child regulates his or her reactivity by inhibiting a dominant response.[15,17,18] As such, an index of self-regulation must take into account both levels of reactivity and regulatory strategies or responses used by the child to meet the required contextual demands.[19]

The development of self-regulation is a result of increasing control over attentional processes, as well as enhanced inhibitory control over motor behavior.[20,21] Mastery of earlier regulatory tasks becomes an important component of later competencies related to behavioral control, interpersonal processes and metacognitions[20] and predicts children's adaptive functioning across domains.[22–24] Furthermore, based on observations that hunger and satiety cues are influenced by stress and socioemotional factors, researchers have started focusing on how individual differences in temperament and self-regulation skills relate to eating and subsequent obesity.[25,26] For example, toddlers' poor self-regulation skills, in particular emotion

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regulation, have been found to predict BMI development and more significant weight problems at age 5 years.[27] Children with impaired capacity to delay gratification at 4 years have also been shown to be more likely to be overweight at 11 years.[28] Additionally, Francis and Susman[29] found that children who showed difficulty across self-control and a delay of gratification task at ages 3 and 5 experienced the most rapid gains in BMI *z*-scores over a 9-year period compared with children who showed high self-regulation. Within the attentional domain, unmedicated children with attention-deficit/hyperactivity disorder have been shown to be 1.5 times more likely to be overweight than age-matched controls.[30]

Another important mechanism entails the role of early temperament and emerging self-regulation in eating behavior—specifically, with regard to expressions of pleasure and inhibitory control. Interestingly, food intake generally stimulates hedonic pathways in the brain such as the nucleus accumbens, with dopamine neurotransmission mediating the reward feelings of food.[31–33] Animal studies have shown that high-fat and sweet foods mobilize greater dopamine levels within the nucleus accumbens compared with healthier/bland food,[32] and thus establish craving pathways in adults.[34] However, it remains unclear whether such craving pathways emerge in early childhood, especially given that high-fat foods in young children may not have the same deleterious consequences as high-fat foods in adults.

Theoretically, there appears to be a reward deficiency syndrome stemming from abnormalities in the dopaminergic system in obese individuals.[35] This underlying biological path may potentially contribute to temperament expressions of low behavioral control via tendencies to experience pleasure. Limited cross-sectional research within the child literature has shown that overweight children score higher on temperament measures of novelty seeking[36] and approach, and exhibit high sensitivity to reward tasks;[37] both of which are thought to tap into enhanced motivation to approach pleasurable activities such as food. However, it remains unclear whether these aspects of early temperament and self-regulation longitudinally predict obesity or if they are a consequence of early overweight status.[38]

It is also important to examine whether early self-regulation skills are associated with other weight-related factors in pre-adolescence. Increased BMI has been associated with body image dissatisfaction, negative eating attitudes/behavior and low self-esteem.[6,9,39] Body image concerns of shape and weight have also been shown to strongly influence eating attitudes and behaviors in normal-weight and obese children.[7,8,9,40] Findings have shown that greater body image dissatisfaction is associated with dieting behaviors,[8,40] disordered eating in preadolescent and adolescent girls[8,41,42] and poor self-esteem and depressive mood in obese adolescents[7,8,42] and adults.[43] Despite the importance of body image dissatisfaction in the etiology of obesity and psychosocial problems, there is very little research on the role of early temperament and self-regulation in the emergence of body image dissatisfaction and eating attitudes.

Psychological risk factors such as high negative emotionality and low levels of persistence in toddlers have been associated with the risk of body image and eating concerns.[44,45] Childhood temperament may indicate an individual's predisposition for affective vulnerabilities associated with impulsivity toward reward or pleasure and negative emotionality. This in turn may be a risk factor for body image dissatisfaction, eating concerns and later disordered eating behaviors. Interestingly, a cross-sectional study by Bulik *et al*.[46] has shown that disordered eating in adult women was associated with high harm avoidance and reward dependence. Confirmation that early temperament and/or deficits in early self-regulation are associated with later body image dissatisfaction and increased BMI would begin to underscore how temperament and self-regulation may be important antecedents for obesity and emotional well-being in preadolescents when outcomes for disordered eating are more prevalent.

In summary, theoretical and empirical data support the need to further examine self-regulation processes and the temperament dimension of pleasure expression in the development of pediatric obesity. We have previously reported that self-regulation skills in toddlers predicted children's BMI and weight problems at age 5 years.[27] The purpose of the current study was to determine if self-regulation skills in toddlers continue to constitute significant risk factors for the development of weight problems at age 10 years. In addition, to our knowledge, no study to date has assessed the extent to which *toddlers' tendencies to express and respond to pleasure* (for example, hedonic positive vocalizations, laughter and so on) predicts weight outcomes. Lastly, we sought to determine whether self-regulation deficits and the temperament dimension of pleasure predict body image concerns in 10-year-old children. We expected that deficits in self-regulation skills in toddlers as well as high temperament levels of pleasure expression would significantly predict higher BMI *z*-scores and body image/eating concerns at age 10 years.

MATERIALS AND METHODS

Participants

Participants for this study included 195 children (114 girls) obtained from a larger ongoing longitudinal study that was approved by the governing institutional review board. The goal for recruitment was to obtain a sample of children who were at risk for developing future externalizing behavior problems that was representative of the surrounding community in terms of race and socioeconomic status. A total of 447 participants were initially recruited at 2 years of age through child care centers, the County Health Department and the local Women, Infants, and Children program. The recruitment sample was diverse with 67% of the children classified as European American, 27% were African American, 4% were biracial and 2% were Hispanic. At age 2 years, the children were primarily from intact families (77%), and families were economically diverse, with Hollingshead (1975) scores ranging from 14 to 66 ($M = 39.56$).

Of the original 447 participants, 399, 365, 356 and 357 participated at the 4-, 5-, 7- and 10-year assessment, respectively. At age 10 years, there were no significant differences between families who did and did not participate in terms of gender, race, socioeconomic status or 2-year externalizing *t*-score. The current study focused on the children for whom laboratory measures at age 2 years and height/weight measurements were obtained at age 4 and 10 years. See Table 1 for participants' ages as there was a range of time in which parents were able to bring their children for the laboratory visit. Complete data were available on 195 children who were racially (70% Caucasian) and economically diverse (Hollingshead scores ranging from 14 to 66, $M = 40.38$) whereas partial data were available on 243 children.

Procedures and measures

The focus of this study involved several laboratory assessments at the 2-year visit. When children were 2 years of age, children and their mothers were videotaped during several laboratory tasks designed to assess self-regulation skills. Task order was standardized and children were given small breaks at the end of each task to ensure no carryover effects were experienced from one task to another. The emotion/behavior tasks described below are considered appropriate for use with young children and are typically used to elicit measures of temperament and regulation.[47,48]

The 2-year self-regulation measure: *sustained attention*

Children were instructed to watch a 5-min segment of the videotape 'Spot', a short story about a puppy exploring a neighborhood. The *overall duration*—proportion of time the child spent looking at the video—indexed sustained attention. The reliability among coders for the overall duration was excellent ($r = 0.98$).

The 2-year self-regulation measure: *emotion regulation*

Children participated in two tasks designed to elicit emotion regulation: the prize in a box task, where a desirable toy (puppet) was placed in a clear

Table 1. Descriptive statistics for all variables

	M	*s.d.*	*Min*	*Max*	N
The 2-year self-regulation/temperament measures					
Age 2-year laboratory visit (months)	31.60	3.67	24	45	421
Emotion reactivity (L)	0.79	0.89	0	4	423
Emotion regulation (L)	3.27	0.89	0	4	423
Sustained attention (L)	0.80	0.18	0.16	1	422
Delay of gratification (L)	0.81	0.31	0	1	274
Temperament: pleasure (P)	5.45	0.65	2.79	6.84	349
The 4-year weight measures					
Age 4-year laboratory visit (months)	53.71	3.72	40	68	374
Height in cm (L)	108.2	5.60	91.40	134.6	356
Weight in kg (L)	18.95	3.36	12.70	42.18	358
Body mass index (L)	16.19	2.18	9.88	31.18	355
Body mass index *z*-score (L)	0.31	1.53	− 11.55	4.83	355
The 10-year weight measures (months)					
Age 10-year laboratory visit	127.74	3.28	118	143	285
Height in cm (L)	147.10	8.00	121.90	175.3	270
Weight in kg (L)	45.05	13.37	24.04	122.47	270
Body mass index (L)	20.56	4.72	13.25	39.87	270
Body mass index *z*-score (L)	0.75	1.11	− 2.61	2.73	270
Overweight concerns-BIEQ (S)	0.68	0.41	0.13	2.0	290
Restraint eating-BIEQ (S)	0.41	0.50	0.00	2.33	290
Diet practices-BIEQ (S)	0.30	0.49	0.00	2.0	290

Abbreviations: BIEQ, Body Image and Eating Questionnaire; L, laboratory measure; P, parent report; S, self-report.

box that the child was unable to open for 2 min, and a high chair task, where the child was placed in a high chair without any toys for 5 min. These tasks were coded for observed emotion regulation and emotional reactivity.[47] For reactivity, distress was defined as when the child whined, fussed, cried or had a tantrum. A *global measure of negative reactivity* was coded on a scale from 0, meaning no negative response, to 4, meaning task ended with the child in extreme distress. Regulation was defined as the overall effectiveness of using various strategies (for example, distraction). A *global measure of regulation* was coded on a scale from 0, meaning dysregulated or no control of distress, to 4, when the child seemed to completely regulate his/her distress during most of the task. The reliability κ for global codes were all above 0.80. The reactivity and regulation codes were averaged across tasks to produce a separate mean score for each. As expected, the measures of emotion regulation and emotional reactivity were highly correlated ($r = -0.91$, $P < 0.001$). Consequently, these constructs were combined by creating *z*-scores of both variables, reverse scoring reactivity and then averaging these standardized scores to create a single measure of emotion regulation.

The 2-year self-regulation measure: reward sensitivity

Children participated in a delay of gratification task in which they were presented with an appealing gift-wrapped box and told there was a gift inside for them but that they could not open it for 2 min. The *total time touching gift,* combined time the child was in contact with the box, was used to assess reward sensitivity/inhibitory control. There was tremendous variability in this *total time touching gift score* in terms of children waiting longer than others before opening the box and also in terms of touching the box throughout the 2 min (for example, children would touch the box but not quite open it). The overall time was reversed score with higher numbers indicating better inhibitory control/lower reward sensitivity. The reliability among coders was excellent ($r = 0.99$).

The 2-year temperament. While in the laboratory, mothers filled out the Toddler Behavior Assessment Questionnaire,[12] a 111-item scale that measures the following temperamental dimensions: activity level, pleasure, social fearfulness, anger proneness and interest/persistence. Caregivers indicate, on a 7-point rating scale from *never* to *always*, how often they observed the specified behavior during the past month. The Toddler Behavior Assessment Questionnaire has been widely used by researchers studying children's temperament and has adequate reliability and validity.[49,50] For the purposes of the current study, we examined the Pleasure scale ($\alpha = 0.84$).

Anthropometrics. Trained research assistants measured children's height and weight (removing shoes and heavy outer clothing) during their 4-, 5-, 7- and 10-year laboratory visit. Weight was measured to the nearest 0.10 kg by using an analog weight scale, and height was measured to the nearest 0.1 cm with a measuring tape. BMI *z*-scores were calculated based on age/gender norms from the Centers for Disease Control and Prevention (CDC).[2]

The 10-year body image/eating concerns. While in the laboratory, children filled out the Body Image and Eating Questionnaire (BIEQ)[51] that assesses concerns about being or becoming overweight (Overweight Scale; 8 items), dieting practices (Diet Scale; 3 items) and restraint of food intake (Restraint Scale; 3 items) on a yes/no or a 4- or 5-point Likert scale format. The BIEQ has adequate reliability and validity.[9,51,52] The current study examined all three subscales: overweight ($\alpha = 0.85$), diet ($\alpha = 0.79$) and restraint ($\alpha = 0.70$).

Data analytic strategy

All analyses were conducted using SPSS 18.0 (SPSS Inc., Chicago, IL, USA). All available data were used for each analysis. First, preliminary analyses were computed. For data reduction purposes, factor analyses were conducted to determine the viability of having a single self-regulation/temperament measure as well as a single body image/eating concern measure. Next, regression analyses were conducted to examine the extent to which early self-regulation/temperament relates to children's BMI *z*-scores and body image/eating concerns at 10 years of age as well as changes in BMI *z*-scores from ages 4 to 10 years. A logistic regression was then conducted to determine whether the 2-year self-regulation/temperament significantly related to children's weight status at age 10 years.

RESULTS

Preliminary analyses

Descriptive Statistics. Descriptive statistics for all of the study's variables are presented in Table 1. An analysis of the demographic variables revealed a significant association between racial status and children's 10-year BMI *z*-scores ($F(2, 252) = 7.82$, $P < 0.01$) and body image/eating concerns ($F(2, 287) = 7.23$, $P < 0.01$) as African-American children had significantly greater BMI *z*-scores and reported greater levels of concern regarding their body image/eating practices at 10 years of age compared with Caucasian children. Preliminary analyses did not yield any other significant

associations between demographic variables (for example, socioeconomic status, sex, maternal education, age) and children's weight outcomes.

Data reduction

A principal component factor analysis with a promax rotation was conducted to determine the feasibility of having a single self-regulation/temperament factor based on the three self-regulation tasks and the temperament dimension of pleasure. From this analysis, two factors emerged with an eigenvalue above 1 ($\lambda = 1.55$ and $\lambda = 1.01$), explaining 38.83 and 25.09% of the total variance across measures for this sample. The first factor contained high loadings across all three self-regulation tasks: emotion regulation (0.64), delay of gratification (0.75) and sustained attention (0.76), but low loading on the pleasure temperament scale (-0.04). The second factor only loaded on the pleasure temperament scale (0.99), with the three self-regulation tasks yielding loadings of <0.05. Hence, a single self-regulation factor was retained with higher scores being indicative of better self-regulation skills, whereas a separate temperament factor was retained with higher scores indicative of more intensive levels of pleasure expression. Another principal component factor analysis with a promax rotation was conducted to determine the feasibility of having a single body image/eating concern factor based on the three scales of the BIEQ. From this analysis, one factor emerged with an eigenvalue above 1 ($\lambda = 2.13$), explaining 70.96% of the total variance across measures for this sample. This factor contained high loadings across all three subscales of the BIEQ: overweight (0.89), diet (0.76) and restraint (0.87). Given this result, a single factor was retained with higher scores indicative of greater body image/eating concerns.

Early self-regulation skills/temperament and 10-year weight outcomes

As seen in Table 2, regression analyses indicated that after controlling for racial status, self-regulation was significantly associated with 10-year BMI *z*-score and body image/eating concerns ($\beta = -0.17$ ($P<0.05$) and $\beta = -0.16$ ($P<0.05$), respectively). Thus, toddlers with better self-regulation skills at age 2 years had lower levels of BMI *z*-scores and fewer body image/eating concerns at age 10 years. The temperament dimension of pleasure was marginally related to 10-year BMI *z*-score ($\beta = 0.12$, $P<0.07$), but not body image/eating concerns ($\beta = 0.03$, $P > 0.05$)). This indicated that toddlers who are reported by parents as having higher levels of pleasure expression at age 2 years had higher levels of BMI *z*-scores at age 10 years.

Early self-regulation skills/temperament as predictors of BMI *z*-score change

Regression analyses were also conducted to determine whether 2-year self-regulation skills/temperament were associated with changes in children's BMI *z*-scores from ages 4 to 10 years. As seen in Table 2, it is first important to note the stability of BMI *z*-score from 4 to 10 years of age as 4-year BMI was a significant and positive predictor of 10-year BMI ($\beta = 0.31$, $P<0.001$). Most importantly, even after controlling for 4-year BMI and racial status, this analysis revealed a significant effect for the self-regulation/temperament variables on 10-year BMI *z*-score. Specifically, self-regulation was significantly associated with change in 10-year BMI *z*-score ($\beta = -0.15$, $P<0.05$). Thus, toddlers with better self-regulation skills at age 2 years were less likely to have increases in BMI *z*-scores from ages 4 to 10 years. There was also a significant effect for the temperament dimension of pleasure ($\beta = 0.13$, $P<0.05$), such that toddlers who are reported by parents as having higher levels of pleasure expression at age 2 years had higher increases in BMI *z*-scores from ages 4 to 10 years.

Table 2. Regression analyses examining predictors of 10-year weight outcomes, body image concerns and change in BMI *z*-score from 4 to 10 years

	β	R^2
The 10-year BMI z-score (L)		
Step 1. Racial status	0.15*	0.03**
Step 2. 2-year self-regulation (L)	−0.17*	0.07**
2-year Temperament: pleasure (P)	0.12$^+$	—
The 10-year Body image/eating concerns (S)		
Step 1. Racial status	0.18**	0.04
Step 2. 2-year self-regulation (L)	−0.16*	0.07
2-year temperament: pleasure (P)	0.03	—
Change in BMI z-score from 4 to 10 years		
Step 1. Racial status	0.11$^+$	0.16***
4-year BMI *z*-score (L)	0.31***	—
Step 2. 2-year self-regulation (L)	−0.15*	0.20**
2-year temperament: pleasure (P)	0.13*	—

Abbreviations: BMI, body mass index; L, laboratory measure; P, parent report; S, self-report. $^+P<0.09$, $^*P<0.05$, $^{**}P<0.01$, $^{***}P<0.001$. Standardized βs are from the final step.

Table 3. Demographic and self-regulation/temperament measures according to 10-year weight group

	Normal weight (n = *148*)	*Overweight/obese* (n = *116*)
Gender		
Male	66[a]	47[a]
Female	82[a]	69[a]
Race		
Caucasian	101[a]	68[a]
African American	40[a]	38[a]
Other	7[a]	10[a]
Socioeconomic status (SES)	40.33 (10.75)[a]	38.84 (11.42)[a]
2-year self-regulation *z*-score (L)	0.16 (0.67)[a]	−0.10 (0.69)[b]
2-year temperament: pleasure scale *z*-score (P)	−0.10 (0.97)[a]	0.22 (0.94)[b]

Abbreviations: L, laboratory measure; P, parent report. Values enclosed in parentheses represent s.d. The χ^2 analyses were conducted to examine gender and racial status differences among normal and overweight/obese groups whereas a *t*-test was conducted to examine differences in SES among weight groups. Significance tests presented for self-regulation and temperament *z*-scores were derived from results of the logistic regression.

Early self-regulation skills/temperament and pediatric obesity

Based on Centers for Disease Control and Prevention (CDC) age norms,[2] children whose BMI values were in the $\geqslant$85th percentile were classified as overweight/obese ($n = 116$), whereas children between the 5th and 84th percentile were classified as normal ($n = 148$). Six children had a BMI $<$5th percentile and were excluded from the analyses. Children in the overweight/obese and normal-weight groups did not significantly differ on any demographic variable. Table 3 depicts weight group descriptive statistics.

A logistic regression was conducted to determine whether 2-year self-regulation and temperament were associated with overweight status at age 10 years. To facilitate interpretation (for example, measure an increase in the risk of obesity rather than a decrease), our self-regulation factor was reverse scored, with

higher scores indicative of worse functioning. We also controlled for 4-year BMI *z*-score. This negative self-regulation factor was significantly associated with weight status (binary outcome, 0 = normal weight and 1 = overweight/obese; odds ratio = 1.74 (1.07–2.86), $P < 0.05$), suggesting that for each unit increase (that is, s.d.) in poor self-regulation, children's odds of being classified as overweight/obese at age 10 years increased by 74%. *Temperament-based pleasure* was also significantly associated with weight status (odds ratio = 1.47 (1.05–2.04), $P < 0.05$), with each unit increase in the intensity in pleasure expression corresponding to an increase of 47% in the odds of children being classified as overweight/obese at age 10 years.

DISCUSSION

This study examined the extent to which individual differences in self-regulation skills and a temperament dimension assessing pleasure expression in toddlers predicted weight outcomes in preadolescence. First and consistent with this study's hypotheses, self-regulation skills in toddlers were associated with both BMI development and pediatric obesity 8 years later. In fact, for every 1 s.d. increase in poor self-regulation, toddlers' likelihood of being classified as overweight/obese at age 10 years increased by 74%, even after accounting for early BMI. Previous longitudinal studies have shown that preschoolers with self-regulation deficits within the behavioral domain (that is, delay of gratification) were more likely to experience weight gain across early childhood.[28,29] We had previously reported that self-regulation skills in toddlers were associated with children's BMI and weight problems at age 5.5 years.[27] With the completion of further longitudinal assessments, our findings indicated that these very early self-regulation deficits continue to constitute significant risk factors for the development of weight problems 8 years later, above and beyond the effects of early BMI. Taken together, these findings showed that broad, generalized self-regulation deficits across domains (that is, emotion, attention, behavioral) were not merely consequences of obesity but may be risk factors that emerge very early in life.

Second, along with self-regulation deficits, our findings showed that toddlers characterized by high temperament expressions of pleasure had higher odds of being overweight/obese at 10 years of age. Previous research examining the relation between early temperament and weight outcomes primarily focused on expressions of negative affect or soothability as risk factors.[53–55] Our study was the first to longitudinally examine the expression of positive affect, specifically pleasure, as a potential risk factor for the development of obesity. The examination of early pleasure responsiveness is crucial, given research in the adult literature suggesting that dopaminergic dysfunction leads to impairments in reward processing that promote obesity.[35] Although our study did not examine dopaminergic responses or food-specific responsiveness, our findings suggest that oversensitivity to a range of novel and pleasurable activities may have been present before the development of obesity and not merely a consequence of early overweight status. The exact mechanisms by which such oversensitivity to pleasure contributes to obesity in children remain unclear. Perhaps oversensitivity to pleasure interferes with satiety processes that are important in telling children when they are feeling satisfied. This type of pleasure responsiveness may also be related to children's unhealthy food preferences (for example, high sugar/sweet) that trigger a greater dopaminergic response.

Third, lower self-regulation skills, but not the temperament dimension of pleasure, may be considered a risk factor for later body image/eating concerns in preadolescence. This unique finding was consistent with emotion regulation theories that posit that deficits in self-regulation may increase behavioral and cognitive vulnerabilities.[24] Research conducted on adolescent girls and college men have found a link between difficulties in emotion regulation and body dissatisfaction.[56,57] It may be the case that body dissatisfaction is maintained by limited self-regulatory skills. This in turn, may create deficits in later coping competencies needed to offset negative affective states produced by appearance-related schemas.

In summary, the current study found that higher levels of self-regulation skills at 2 years of age were negatively associated with higher BMI scores at age 10 years, decreased likelihood of experiencing greater increases in BMI from 4 to 10 years of age and negatively related to body/image eating concerns at age 10 years. Conversely, lower levels of self-regulation skills at 2 years of age were associated with overweight status at 10 years of age. The temperament dimension of pleasure was related to an increased likelihood of experiencing higher increases in BMI from 4 to 10 years of age and was associated with weight status at age 10 years. Strengths of this study included the multidimensional assessment of self-regulation across different laboratory tasks, the inclusion of a temperament measure and the 8-year longitudinal follow-up of children's BMI and body image/eating concerns.

Limitations of the study included not having information on child eating behaviors or parental weight as this was not the primary aim of the study design. It is also important to point out that despite our longitudinal design and attempts in controlling early weight status, we cannot affirm a causal link between self-regulation and the development of obesity. It is possible that the observed association between self-regulation at 2 years and obesity at 10 years of age is a result of an unmeasured variable such as physical activity. Nevertheless, our results do provide further evidence for the importance of examining toddlers' early self-regulation skills and temperament as risk factors for the development of obesity. Given the strong effect of parental weight status on children's weight status,[58] future studies should examine the extent to which parenting practices influence child weight status via child deficits in self-regulation and high-intensity expression of pleasure.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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