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Observed Self-Regulation is Associated with Weight in Low-Income Toddlers

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Abstract

Obesity emerges in early childhood and tracks across development. Self-regulation develops rapidly during the toddler years, yet few studies have examined toddlers' self-regulation in relation to concurrent child weight. Further, few studies compare child responses in food and non-food-related tasks. Our goal was to examine toddlers' observed behavioral and emotional self-regulation in food and non-food tasks in relation to their body mass index z-score (BMIz) and weight status (overweight/obese vs. not). Observational measures were used to assess self-regulation (SR) in four standardized tasks in 133 low-income children (M age=33.1 months; SD=0.6). Behavioral SR was measured by assessing how well the child could delay gratification for a snack (food-related task) and a gift (non-food-related task). Emotional SR was measured by assessing child intensity of negative affect in two tasks designed to elicit frustration: being shown, then denied a cookie (food-related) or a toy (non-food-related). Task order was counterbalanced. BMIz was measured. Bivariate correlations and regression analyses adjusting for child sex, child race/ethnicity, and maternal education were conducted to examine associations of SR with weight. Results were that

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better behavioral SR in the snack delay task associated with lower BMIz (β=−0.27, p<.05) and lower odds of overweight/obesity (OR=0.66, 95% CI 0.45, 0.96), but behavioral SR in the gift task did not associate with BMIz or weight status. Better emotional SR in the non-food task associated with lower BMIz (β= −0.27, p<.05), and better emotional SR in food and non-food tasks associated with lower odds of overweight/obesity (OR=0.65, 95% CI 0.45, 0.96 and OR=0.56, 95% CI 0.37, 0.87, respectively). Results are discussed regarding how behavioral SR for food and overall emotional SR relate to weight during toddlerhood, and regarding early childhood obesity prevention implications.

Keywords

Toddler self-regulation; emotion; behavior; weight; childhood obesity; observational study

Introduction

Self-regulation (SR) can be defined as the capacity to control one's behaviors and emotions when challenged in order to pursue a goal. SR is proposed to underlie many health-related behaviors in adults, particularly eating and weight management (Vohs & Heatherton, 2000). Nearly one in five US children are obese, with a body mass index (BMI) at or above the 95th percentile for age and sex, by age four years (Anderson & Whitaker, 2009). Given that obesity, once established, is highly likely to track throughout childhood and into adulthood (Freedman et al., 2005; Nader et al., 2006) there is a critical need to understand the mechanisms via which obesity develops prior to age 5 years. Children dramatically increase their behavioral and emotional SR skills across the toddler period (approximately 18 months to 3 years) as they learn how to control their impulsive behaviors and emotional responses when placed in situations that challenge these SR capacities (Calkins, Brownell, & Kopp, 2007; Jennings, 2004; Kochanska, Murray, & Harlan, 2000). Furthermore, weight trajectories prior to age 3 years are strong independent predictors of later overweight (Ong & Loos, 2006; Slining, Herring, Popkin, Mayer-Davis, & Adair, 2013). Both SR and eating behaviors that may contribute to overweight are shaped early in life by biological as well as behavioral and social-relational processes such as modeling by parents and caregivers (Blissett, Haycraft, & Farrow, 2010; Calkins et al., 2007). As early childhood SR can be enhanced through classroom-based (Blair & Diamond, 2008) and parenting-focused interventions (Chang, Shaw, Dishion, Gardner, & Wilson, 2014), it is important to consider SR during the toddler period as a potential pathway for health promotion, specifically obesity prevention in early childhood (Miller et al., 2012).

Behavioral SR and Weight in Children

Impulsivity, or a lack of inhibitory control, is an indicator of poor behavioral SR that has been associated with higher weight status and BMI among school-aged children and adolescents (see(Liang, Matheson, Kaye, & Boutelle, 2014; Thamotharan, Lange, Zale, Huffhines, & Fields, 2013) for reviews). Although the association is hypothesized to operate through an impulsive child's inability to delay gratification for tempting food (Nederkoorn, Braet, Van Eijs, Tanghe, & Jansen, 2006), many studies of school-aged children assess

behavioral SR in non-food tasks (C. Braet, Claus, Verbeken, & Van Vlierberghe, 2007; Cserjesi, Molnar, Luminet, & Lenard, 2007; Delgado-Rico, Rio-Valle, Gonzalez-Jimenez, Campoy, & Verdejo-Garcia, 2012; Duckworth, Tsukayama, & Geier, 2010; Fields, Sabet, & Reynolds, 2013; Nederkoorn, Jansen, Mulkens, & Jansen, 2007; Verbeken, Braet, Claus, Nederkoorn, & Oosterlaan, 2009). Some researchers have suggested that assessing SR failures specifically for food may be more important than general inhibitory control failures for weight outcomes, as children with food-specific SR failures likely eat more obesogenic foods (Nederkoorn, Coelho, Guerrieri, Houben, & Jansen, 2012). Yet, studies typically do not compare behavioral SR in food-related and non-food-related tasks with respect to child weight, and the few studies that have done so in younger children have yielded mixed results (Francis & Susman, 2009; Hughes, Power, O'Connor, & Orlet Fisher, 2015). It is therefore not well-understood whether poor behavioral SR in general or specifically in food-related contexts is most relevant for obesity risk during early childhood.

A number of studies have found that behavioral SR in food tasks, specifically the ability to delay gratification for food during the preschool years (3–5 years of age) predicts later, though not concurrent weight outcomes (see (Caleza, Yañez-Vico, Mendoza, & Iglesias-Linares, 2016) for recent review). Poorer behavioral SR for food at preschool-age has been associated with higher BMI in middle childhood (ages 11–12 years) (Francis & Susman, 2009; Seeyave et al., 2009) and in adulthood (Schlam, Wilson, Shoda, Mischel, & Ayduk, 2013). Yet, concurrent associations between behavioral SR for food and child weight during this frequently-studied 3- to -5-year age range are inconsistent. Two studies reported no concurrent association between behavioral SR for food and weight at this age (Francis & Susman, 2009; Hughes et al., 2015), although one of these studies found associations between poorer behavioral SR in a non-food task and higher concurrent BMI (Hughes et al., 2015). Another study found that behavioral SR in a snack task at age 3 years was unrelated to concurrent BMI and associated with lower BMI by age 4 years for girls only (Silveira et al., 2012). Finally, in a small study of 3- to 6-year olds (n=37), low executive function skills, which often underlie poor behavioral SR, were associated with obesity-promoting eating behavior but not with BMI (Pieper & Laugero, 2013). This study did not assess behavioral SR in food tasks, however.

Behavioral SR for food has not been studied in relation to weight outcomes in children younger than age 3 years. This is an important oversight because children are just beginning to develop independent SR capacities due to their rapidly increasing cognitive and social skills (Calkins et al., 2007) and capacity for goal-directed behavior (Jennings, 2004) during the toddler period. Thus, although parents continue to play a role, children's self-directed abilities to delay gratification for tempting foods and increased autonomy over food choices may start to drive their eating behaviors and over time, their risk for overweight. Assessing whether poor behavioral SR is associated with early weight outcomes prior to age 3 years is critical because weight trajectories prior to age 3 predict adult weight status (Slining et al., 2013). As childhood obesity rates are high as of the preschool years (Anderson & Whitaker, 2009), interventions have therefore proposed focusing on behavioral SR as a mechanism for obesity prevention during early childhood (Miller et al., 2012). The only prior study to examine behavioral SR and weight in children under 3 years of age used non-food tasks, finding that behavioral inhibition in a gift delay task at age 2 years was associated with

lower concurrent child BMI, as well as BMI at age 5 (Graziano, Calkins, & Keane, 2010) and age 13 years (Graziano, Kelleher, Calkins, Keane, & Brien, 2013). Behavioral SR for food was not examined in this study.

Thus, the literature on how behavioral SR in food and non-food tasks relates to concurrent child weight during early childhood is inconsistent and few studies have compared behavioral SR in food and non-food tasks. Furthermore, there is a gap in the science regarding how behavioral SR in food- and non-food tasks relates to weight in children younger than 3 years of age. Understanding children's capacity to control their behavioral impulses in food- and non-food tasks during the toddler period when weight trajectories are becoming established and independent SR skills are rapidly developing is important, as identifying early-emerging contextual specificity in behavioral SR skills may provide insight into later obesity risk.

Emotional SR and Weight in Children

Emotional SR, or the capacity to remain calm in challenging or frustrating situations, is another key aspect of SR that develops across toddlerhood, and may be important in decreasing potential stress-eating pathways to obesity (Groesz et al., 2012). Very young children who request to eat when they are frustrated as an emotion regulation strategy may be at risk for excessive weight gain over time if they routinely engage in this behavior; indeed, preschool-aged children whose parents reported frequent temper tantrums over food were heavier (Agras, Hammer, McNicholas, & Kraemer, 2004). Emotional over-eating as measured by the Child Eating Behavior Questionnaire (Wardle, Guthrie, Sanderson, & Rapoport, 2001) has been shown to increase from early to middle childhood (Ashcroft, Semmler, Carnell, van Jaarsveld, & Wardle, 2007) and has been associated with higher weight outcomes in preschool (Domoff, Miller, Kaciroti, & Lumeng, 2015) and obesity among school-aged children (C Braet & Van Strien, 1997). Studies have also shown consistent associations between early negativity in infants and higher weight outcomes (Carey, 1985; Darlington & Wright, 2006) see (Anzman-Frasca, Stifter, & Birch, 2012) for review). Findings therefore suggest that poor emotional SR early in development may be important, but almost all of these prior studies have relied on parent report.

Using observational methods to assess emotional SR in young children may yield additional information about the child's ability to regulate emotions in the moment and have less potential bias than parent report. Of the two studies we could identify that used observational measures to assess emotional SR and weight in young children, one study found that observed but not parent-reported infant negativity was associated with faster infant weight gain from 1 to 3 years, that the association was stronger when parents had lower self-efficacy, and that poorer overall maternal self-regulation predicted higher child weight (Anzman-Frasca, Stifter, Paul, & Birch, 2013). Another study found that poorer observed emotional SR at age 2 years predicted higher child BMI and weight status at age 5 years (Graziano et al., 2010). Both of these studies had relatively small samples (n=72 and 57, respectively) and only assessed emotional SR in non-food frustration tasks. One additional small study of preschool-aged children (n=25) found that children whose mothers used food as an emotion regulation strategy ate more snack food during a negative mood

induction (compared to a neutral interaction) than did other children (Blissett et al., 2010). With the exception of Agras et al., however, which relied on parent report, we were unable to find studies examining emotional SR in food-related tasks and weight in early childhood, and no studies that assessed this construct observationally.

Current Study

Our overarching theoretical model is that both behavioral and emotional SR may be involved in early pathways to obesity. The toddler age period is formative for the development of both SR and eating behavior habits, as well as the establishment of long-term weight trajectories (Calkins et al., 2007; Deming, Briefel, & Reidy, 2014). Therefore, it is essential to understand how early-emerging SR capacity in both food and non-food task contexts relates to child weight at this period. The one study (Graziano et al., 2010) that examined both emotional and behavioral SR in relation to weight in children under age 3 years used non-food tasks and was based on a small sample of toddlers (n=57) at low socioeconomic risk. Yet, nearly half (49%) of infants and toddlers in the United States are low-income (Addy, Engelhardt, & Skinner, 2013) and low-income children are up to twice as likely to be obese (Pan, May, Wethington, Dalenius, & Grummer-Strawn, 2013). It is vital to identify malleable mechanisms associated with obesity that emerge during this developmental period in order to effectively intervene with this high-risk group.

The goal of the current study was therefore to examine behavioral and emotional SR in food- and non-food tasks in relation to weight in a sample of low-income toddler-aged children. We hypothesized that poorer SR would be associated with higher body mass index z-score (BMIz score), and that there would be stronger associations between BMIz and SR in food compared to non-food tasks. Although we did not have a specific hypothesis regarding behavioral versus emotional aspects of SR in relation to BMIz, emotional overeating has been found to increase from preschool- to school-age (Ashcroft et al., 2007) and has been related to obese weight status in school-aged children (C Braet & Van Strien, 1997). Therefore it could be that in this toddler-age cohort, behavioral SR would more strongly relate to concurrent weight outcomes than emotional SR.

2. Method

2.1. Participants and Recruitment

Study participants were recruited through flyers posted in community agencies serving low-income families (e.g., Early Head Start; Women, Infant, and Children (WIC) Programs) between 2011 and 2014 (Asta et al., 2016). The study was described as examining whether children with different levels of stress eat differently. Inclusion criteria were that the biological mother was the child's legal guardian, had an education level less than a 4-year college degree, and was at least 18 years old; the family was eligible for Head Start, WIC or Medicaid and was English-speaking; and the child was between 21 and 27 months old, was born at a gestational age ≥ 36 weeks, had no significant health problems, and had no food allergies or significant perinatal or neonatal complications, and no significant developmental delays. Mothers provided written informed consent. The University of Michigan Institutional Review Board approved the study.

Characteristics of the sample are shown in Table 1. The sample was 49.6% male and 54.9% non-Hispanic white. The mean child BMIz score was 0.48 (SD 0.9); 26.3% of the sample was overweight/obese (BMI ≥ 85th percentile for age and sex). Over one-third of mothers (39.1%) had an education level of a high school diploma or less; 31.2% of families were food insecure, and 18.9% were headed by single mothers.

Mother-child dyads participated in data collection at child ages 21, 27, and 33 months; the 33-month assessments are the focus of the current report. A total of 159 dyads participated in the 33-month visit. The current report is limited to children who participated in the SR tasks and anthropometric measurement at 33 months (n=133). The 133 participants included in this analysis did not differ from the excluded participants from the parent study (n=26) with regard to child sex, child age, child BMIz, maternal BMI, maternal education, or food security. Of the children with complete data included in this report, 18.9% of participants had a single mother family structure, compared to 42.1% of those not included (p=0.02).

2.2. Study Design and Procedures

This was an observational study. At 33 months, each child was weighed and measured on the first data collection visit. On a subsequent day, each child participated in standardized SR tasks that were individually administered in the home (mean time between visits: 4.4 days, SD = 8.6 days). Tasks were administered in a counterbalanced order (either all food tasks first and then all non-food tasks, or vice versa; t- tests indicated no order effects on self-regulation outcomes; all p's<0.78). All tasks were administered by a trained bachelor's-level research assistant and videotaped for coding. The mother was asked not to interact with her child during the protocol (with the exception of the no-touch cookie task, Section 2.2.1). The two food-related and two non-food-related SR tasks that are the focus of this report are described below.

2.2.1. SR Tasks

Food-Related Behavioral SR: Snack Delay: The snack delay task is a food-focused task used to assess behavioral SR in toddlers (Kochanska et al., 2000). The child was seated in a child-sized chair and asked to place his or her hands on a table where a snack (red Froot Loop) was placed under a transparent cup. The examiner explained "It's a game where you wait for me to ring this triangle before you eat a snack", and demonstrated ringing the triangle with a wand and eating the snack (to avoid the food neophobia common at this age (Cashdan, 1994)). The examiner reminded the child of the rule before each trial ("After I ring, you can eat."). For each trial, the examiner lifted the wand halfway through the waiting period, but did not ring the triangle. Four trials were conducted and scored per standard methods with delay times of 5, 10, 15, and 20 seconds (Kochanska et al., 2000). The child's response was scored as 0=eats snack before wand is lifted; 1=eats snack after wand is lifted, but not rung; 2=touches wand, triangle or cup before wand is lifted; 3=touches wand, triangle or cup after the wand is lifted; and 4=waits for the ring before touching wand, triangle or cup. Scores were averaged across all trials. Higher scores indicate better behavioral SR.

Food-Related Emotional SR: No-Touch Cookie: The no-touch cookie task, also based on prior work, is a food-focused task designed to elicit frustration and thus assess emotional SR capacity (Gilliom, Shaw, Beck, Schonberg, & Lukon, 2002). The examiner showed the child a cookie, then gave the mother the cookie in a clear plastic bag and instructed the mother to complete questionnaires and not let the child have the cookie until the examiner said it was time. The examiner said to the child, "I'm going to give this cookie to your mom to hold while she fills out some papers and I do some work. Don't touch the cookie until I come back. You can have the cookie after she's finished." The examiner began timing for 2 minutes and then the mother gave the cookie to the child. The intensity of the child's negative affective displays were rated from video on a 3-point scale during each 10-second intervals during the task (0=no distress/frustration; 1=mild distress/frustration; 2=moderate/intense distress/frustration; Kappa = 0.79). The mean intensity of child negative affect was calculated and values were reverse-coded such that higher scores indicate better emotional SR.

Non-Food-Related Behavioral SR: Gift Delay: The gift delay task is a non-food task that has been used in prior work to assess behavioral SR in toddlers (Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996; Kochanska et al., 2000). The examiner told the child, "I have a present for you in this bag, but I want to wrap it so it will be a surprise. Sit here and don't look." The child sat in the child-sized chair and the examiner stood behind the child and pretended to wrap a gift by crinkling paper in a bag for 60 seconds. Child latency to peek at the examiner was coded from video (kappa = 1.0). Number of seconds prior to peeking was calculated (equal to 60 if no peeking). Longer latency to peek times indicate better behavioral SR.

Non-Food-Related Emotional SR: No-Touch Toy: The no-touch toy task, also based on prior work (Putnam, Spritz, & Stifter, 2002) is a non-food task designed to elicit frustration by introducing an appealing toy but not allowing the child to play with it. The examiner brought out a novel toy (Fisher Price Little People Zoo Talkers Animal Sounds) and said, "See the toy? Don't touch", then demonstrated the features to the child without letting the child touch. Then the examiner said "I want to play with you but I need to go do work. Don't touch the toy until I come back." The examiner began timing and left the room for 60 seconds, then returned to play with the toy with the child. As in the cookie task, the intensity of the child's negative affective displays was rated on a 3-point scale during each 10-second interval during the 1-minute task (0=none; 1=mild distress/frustration; 2=moderate/intense distress/frustration; Kappa = 0.91). The mean intensity of child negative affect during the task was calculated and values were reverse-coded such that higher scores indicate better emotional SR.

2.2.2. Anthropometry—Weight and height of the child were measured by trained research staff certified in standardized measurement technique. Children were weighed and measured twice. If measurements were off by 0.5 centimeter or more for height, or by 0.1 kilogram or more for weight, children were measured two additional times. Child BMI was calculated and BMI z-score (BMIz) was generated based on the US Centers for Disease Control Growth Charts (Kuczmarski et al., 2002). Weight status was categorized as

overweight/obese (BMI ≥ 85th percentile for age and sex) vs. not overweight (BMI < 85th percentile for age and sex). Mothers' weight and height were measured and BMI calculated.

2.2.3. Covariates—Mothers reported child sex and birth date. Mothers were asked to report their child's race (response options included White, Black, American Indian or Alaska Native, Asian or Pacific Islander, Biracial, or Other) and ethnicity (Hispanic Latino or not Hispanic or Latino); for this analysis child race/ethnicity was categorized as non-Hispanic white versus not. Mothers reported maternal education (more than a high school diploma versus not), and family structure (single mother versus not). Mothers also completed the 18-item US Department of Agriculture Household Food Security Survey (Bickel, Nord, Price, Hamilton, & Cook, 2000) which categorizes households as food secure versus not.

2.3. Statistical Analysis

Analyses were conducted using SAS 9.4 (SAS Institute Inc., Cary, NC). Univariate statistics were used to describe the sample. Bivariate analyses to examine associations between SR variables and BMIz and between potential covariates and BMIz were conducted using t-tests and correlations. Five multivariate linear regression models were used to predict child BMIz score at 33 months from behavioral and emotional SR variables in food tasks (Snack Delay and No-Touch Cookie, respectively), behavioral and emotional SR in non-food tasks (Gift Delay and No-Touch Toy, respectively), and a final model that included all SR predictors. We also ran each of the above models using logistic regression analysis to predict child overweight/obese weight status as an outcome. Demographic covariates (child sex, child race/ethnicity, maternal education) were also entered in each model. A p-value of $< .05$ was considered statistically significant.

3. Results

The means for each SR variable and bivariate associations among SR variables and child BMIz score are presented in Table 2. Child emotional SR was positively associated across food and non-food tasks ($p<.05$). No other SR variables were associated with one another.

Poorer behavioral SR in the food task (Snack Delay) and poorer emotional SR in both the food and non-food tasks were associated with higher child BMIz score.

Results from adjusted linear regression models predicting BMIz are presented in Table 3. Adjusting for covariates (child sex, child race/ethnicity, maternal education), better behavioral SR in the food task only (Snack Delay) was associated with lower child BMIz score ($\beta= -0.27$, $p<.05$). Better emotional SR in the non-food task was associated with lower child BMIz score ($\beta= -0.27$, $p<.05$). When all SR variables were entered into the model, both behavioral SR in the food task and emotional SR in the non-food task remained as significant predictors. The overall models for Behavioral SR in the food task, Emotional SR in the non-food task, and the model with all SR variables each reached significance, and the model with all SR variables accounted for 9% of the variance in child BMIz score (R^2 adjusted for the number of variables in the model). No covariates were associated with child BMIz score.

Results from adjusted logistic regression models predicting weight status are presented in Table 4. Adjusting for covariates (child sex, child race/ethnicity, maternal education), better behavioral SR in the food task, and better emotional SR in both food and non-food tasks were associated with lower odds of overweight/obesity. Specifically, for each unit increase in behavioral SR for food, odds of overweight/obesity decreased by 0.66 (95% CI: 0.45, 0.96), for each unit increase in emotional SR for food, odds of overweight/obesity decreased by 0.65 (95% CI: 0.45, 0.95), and for each unit increase in emotional SR for non-food, odds of overweight/obesity decreased by 0.56 (95% CI: 0.37, 0.87). When all SR variables were entered into the model, behavioral SR in the food task remained a significant predictor and emotional SR for non-food became marginal. The model with all SR variables fit the data significantly better than the intercept-only model (likelihood ratio test $\chi^2(7)= 16.35$, $p<.05$). No covariates were associated with child weight status.

4. Discussion

The current study had four main findings. First, at 33 months of age, child behavioral SR (ability to wait) in a food delay task was associated with lower concurrent child weight (BMIz score) and lower odds of overweight/obese weight status. Second, child behavioral SR in a non-food delay task at this age was not associated with child BMIz or overweight/obese weight status. Third, better emotional SR (less negative affect) in both food and non-food frustration tasks was associated with lower odds of overweight/obese weight status and better emotional SR in the non-food task was associated with lower concurrent BMIz score. Results held when analyses were adjusted for child sex, child race/ethnicity, and level of maternal education. Fourth, when all SR predictors were entered in the model, behavioral SR for food remained a statistically significant predictor of both BMIz and overweight/obese weight status, and emotional SR for non-food remained a significant predictor of BMIz, but not weight status. To our knowledge, no other published reports have examined behavioral and emotional SR in food- and non-food tasks in toddler-aged children. The only other studies to assess observed behavioral or emotional SR in relation to concurrent weight in children this young were based on smaller, lower-risk samples and did not examine emotional or behavioral SR in food tasks (Anzman-Frasca et al., 2013; Graziano et al., 2010). Results from the current study support the perspective that behavioral SR for food, but not poor behavioral SR in general, may be a pathway to obesity risk (Nederkoorn et al., 2012). Findings regarding emotional SR are consistent with studies using smaller samples that found parent-reported child negative affect to be associated with rapid weight gain during infancy (Carey, 1985; Darlington & Wright, 2006).

Prior work has found associations between observed behavioral SR during early childhood and faster rates of weight gain (Francis & Susman, 2009) or higher weight status (Graziano et al., 2010; Schlam et al., 2013; Seeyave et al., 2009) later in development (see (Caleza et al., 2016) for a review). With the exception of Graziano et al., who used non-food stimuli with toddlers, most prior work with young children has used food as a stimulus and participants were older than the children in the current study (all > 3 years of age). Thus, the current study is the first to compare observed behavioral SR in food vs. non-food tasks in toddler-aged children. It has been suggested that children consider and evaluate foods differently from other artifacts, such as toys, from very early in development (Shutts,

Kinzler, & DeJesus, 2013). Thus, children may make distinctions between choosing to wait to receive a toy versus choosing to wait to eat a treat. Our finding that at 33 months of age, poorer observed behavioral SR for food was associated with greater BMIz, whereas poorer behavioral SR for a desired gift was not, suggests that toddlers' poor behavioral SR specifically in response to food may be critical for understanding and preventing obesity risk. Indeed, behavioral SR for food was the only aspect of SR that remained a significant of overweight/obese weight status once other aspects of SR were included in the model. General impulsivity at this age may be a somewhat less relevant signal for obesity risk, at least in the population studied, or we may have had floor effects for behavioral SR in the non-food task, as children waited only a few seconds before touching the toy; larger effects may be seen in more heterogeneous samples.

Reward responsivity may play a role in this process, such that children who are highly food-responsive may experience more SR failures in food contexts (Carnell & Wardle, 2008). During toddlerhood, children begin to develop strong food preferences and independent eating habits (Cashdan, 1994) and also gain increased access to palatable foods (e.g., desserts) that can promote obesity. Reward responsivity may therefore be an important child factor that could contribute to behavioral SR difficulties specifically around obesity-promoting foods during very early childhood and thereby increase later obesity risk. As parents can shape both SR development and the availability of food choices, it may be particularly important for parents of young children who are very responsive to food rewards to develop strategies to limit access to obesogenic foods, as well as actively aid children in developing SR capacity when they are faced with these food options.

In contrast to behavioral SR, toddlers' emotional SR in both food- and non-food tasks was associated with weight outcomes, although only in individual regression analyses. Specifically, poorer emotional SR (i.e., higher intensity negative affect) in the non-food task was associated with higher BMIz, and poorer emotional SR in both food- and non-food tasks was associated with greater odds of overweight/obesity. This finding is consistent with literature showing that difficult temperament in infancy, particularly distress to limitations, is associated with faster weight gain (Carey, 1985; Darlington & Wright, 2006). A unique contribution of the current study was our use of direct observational methods to assess emotional SR in frustration tasks, compared to prior work which has primarily relied on parent reports. Our results were consistent with the one other study that used observational methods to assess emotional SR in relation to weight in toddlers, but that study only examined emotional SR in non-food tasks and in a smaller, lower-risk sample (Graziano et al., 2010). One study of infants also found that observed negativity was associated with increased weight gain across the infant-to-toddler period (Anzman-Frasca et al., 2013). Thus, results from the current study support and extend prior work in this area and suggest that infants and toddlers who are prone to distress in the face of frustration may be at risk for excessive weight gain. Associations may develop through multiple pathways, including parenting. For example, children who exhibit high negativity as infants may be fed frequently as a soothing strategy, or may sleep less, which has been associated with childhood obesity risk (Chen, Beydoun, & Wang, 2008). Associations may also be bidirectional; for example, hungrier infants may sleep less and cry more. Such patterns are shaped through interactions with parents early in development, and can become increasingly

established as children grow older and more able to control their own behavior. Therefore, toddlerhood is an important transitional period in which to identify early-life risk factors that could be the focus of developmentally-sensitive childhood obesity prevention efforts.

5. Study Strengths and Limitations

As with all studies the current work had limitations. Although we selected tasks in order to compare behavioral responses to delay of gratification and emotional responses to frustration, the frustration tasks also contained an element of delay. The cookie task was also the only task that included the parent, which may have introduced an additional influence. We did not consider parenting in this study as we were primarily focused on child SR responses; however, parenting is a central influence on child SR (Kochanska et al., 2000). As well, both general and feeding-specific parenting have been associated with child weight in prior work (Vollmer & Mobley, 2013). Recent research on early childhood weight gain has highlighted the need to consider child characteristics in relation to parenting, finding that observed infant negative reactivity was associated with weight gain from age 1 to 3 years only in the context of lower parent self-efficacy (Anzman-Frasca et al., 2013) and that observed maternal restrictive feeding was associated with increased BMI for girls, but with declines in BMI for boys from ages 2–6 years (Hittner, Johnson, Tripicchio, & Faith, 2016). Therefore, articulating how both general and food-related parenting may shape or interact with child SR in predicting weight may be an important future research direction. As the study design was correlational we cannot infer causality, and results may not be generalizable to populations other than low-income, toddler-aged children. Finally, the effect sizes were also relatively small, and some of the overall models were not significant. Yet, given that behavioral SR for food still predicted both BMIz and overweight/obesity outcomes after accounting for the variance explained by other SR variables, results suggest it will be important to examine this aspect of SR in future work.

Despite these limitations, the current study had notable strengths. We conducted observational assessments of SR in both food and non-food tasks, which is a unique contribution to the literature. We also considered both emotional and behavioral aspects of SR which had not been examined in relation to weight outcomes among children this age. Given the high obesity rates among low-income children (Pan et al., 2013) the fact that our sample was low-income is also a strength as it allowed a characterization of these processes in a population at high risk for childhood obesity.

6. Conclusions

The current study provides observational evidence that behavioral SR difficulty in food-related, but not non-food tasks is associated with greater weight in low-income, toddler-aged children. Greater emotional SR difficulty was associated with greater weight across different tasks. Findings support and extend prior work by using observational methods and suggest the toddler period may be important in identifying child factors that may promote later obesity risk.

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Abbreviations

BMIz	body mass index z-score
SR	self-regulation
BMI	body mass index

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Highlights

- We observed behavioral and emotional self-regulation in low-income 33-month-olds.
- Self-regulation was related to weight (BMIz and overweight/obesity), but associations varied by task type.
- Poorer behavioral self-regulation in food tasks was associated with higher weight.
- Poorer emotional self-regulation in food- and non-food tasks related to higher weight.

Table 1

Characteristics of the sample (n = 133)

Variable	N (%) or Mean (Standard Deviation)
Child	
Sex	
Female	67 (50.4%)
Male	66 (49.6%)
Race/Ethnicity	
non-Hispanic white	73 (54.9%)
Hispanic or not white	60 (45.1%)
BMI z-score	0.48 (0.96)
Overweight/obese (BMI ≥ 85th percentile)	35 (26.3%)
Maternal	
BMI (kg/m^2)	32.72 (10.63)
Education	
High school or less	52 (39.1%)
More than high school	81 (60.9%)
Family	
Food insecurity	
Food insecure	38 (31.2%)
Food secure	84 (68.9%)
Family Structure	
Single mother	23 (18.9%)
Not single mother	99 (81.1%)

Table 2

Correlations: Behavioral SR and emotional SR in food and non-food tasks and child BMIz (n=133)

	1	2	3	4	M (SD)
1. Behavioral SR: Food (Snack Delay)					3.11 (1.08)
2. Emotional SR: Food (No Touch Cookie)	0.12				1.91 (0.27)
3. Behavioral SR: Non-Food (Gift Delay)	0.10	0.11			5.20 (12.68)
4. Emotional SR: Non-Food (No Touch Toy)	0.14	0.48**	−0.02		1.95 (0.15)
5. Body mass index z-score (BMIz)	−0.27**	−0.16*	0.05	−0.27**	0.48 (0.96)

Note.

* $p < 0.05$.

** $p < 0.01$.

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Table 3

Regression Analyses: Behavioral SR and emotional SR in food and non-food tasks predicting child BMIz (n=133)

	Food Tasks		Non-Food Tasks		All tasks
	Behavioral SR (Snack Delay)	**Emotional SR (No Touch Cookie)**	**Behavioral SR (Gift Delay)**	**Emotional SR (No Touch Toy)**	
Model adjusted R^2	0.05	0.01	−0.02	0.06	0.09
F(Model)	F(4,128)=2.79 *	F(4,128)=1.25	F(4,128)=0.42	F(4,128)=2.97 *	F(7,125)=2.97 **
	β (SE)	*β (SE)*	*β (SE)*	*β (SE)*	*β (SE)*
Covariates					
Child is female (referent: male)	0.14 (0.17)	0.16 (0.17)	0.15 (0.18)	0.13 (0.17)	0.14 (0.17)
Child is Hispanic or not white (referent: non-Hispanic white)	0.10 (0.17)	0.12 (0.17)	0.12 (0.18)	0.16 (0.17)	0.12 (0.17)
Maternal education level is high school or less (referent: more than high school)	0.01 (0.17)	−0.05 (0.18)	−0.04 (0.18)	−0.03 (0.17)	0.05 (0.17)
SR Variables					
Behavioral SR: Food	−0.27 (0.09) **				−0.24 (0.09) **
Emotional SR: Food		−0.16 (0.09) ^			−0.04 (0.10)
Behavioral SR: Non-Food			0.05 (0.09)		0.07 (0.09)
Emotional SR: Non-Food				−0.27 (0.08) **	−0.22 (0.10) *

Note: Standardized beta coefficients.

^ $p < 0.10$.

* $p < 0.05$.

** $p < 0.01$.

Table 4

Logistic Regression Analyses: Behavioral SR and emotional SR in food and non-food tasks predicting child overweight/obese (BMI ≥ 85th percentile for age and sex) (n=133)

	Food Tasks		**Non-Food Tasks**		**All tasks**
	Behavioral SR (Snack Delay)	**Emotional SR (No Touch Cookie)**	**Behavioral SR (Gift Delay)**	**Emotional SR (No Touch Toy)**	
$\chi^2(df)$	5.61 (4)	6.27 (4)	1.77 (4)	9.41 (4)^	16.35 (7)*
	OR (95% CI)	*OR (95% CI)*	*OR (95% CI)*	*OR (95% CI)*	*OR (95% CI)*
Covariates					
Child is female (referent: male)	1.04 (0.47, 2.29)	1.10 (0.49, 2.43)	1.06 (0.49, 2.31)	0.99 (0.44, 2.23)	1.07 (0.47, 2.48)
Child is Hispanic or not white (referent: non-Hispanic white)	1.35 (0.61, 2.97)	1.41 (0.63, 3.11)	1.37 (0.63, 2.99)	1.55 (0.69, 3.47)	1.39 (0.60, 3.20)
Maternal education level is high school or less (referent: more than high school)	1.03 (0.46, 2.35)	0.94 (0.41, 2.12)	0.97 (0.43, 2.18)	0.97 (0.42, 2.24)	1.21 (0.50, 2.89)
SR Variables					
Behavioral SR: Food	0.66 (0.45, 0.96)*				0.66 (0.44, 0.99)*
Emotional SR: Food		0.65 (0.45, 0.95)*			0.71 (0.45, 1.12)
Behavioral SR: Non-Food			1.20 (0.84, 1.72)		1.33 (0.90, 1.99)
Emotional SR: Non-Food				0.56 (0.37, 0.87)*	0.62 (0.37, 1.02)^

Note: Standardized beta coefficients.

^ $p < 0.10$.

* $p < 0.05$.

** $p < 0.01$.