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Parent-child interaction, self-regulation, and obesity prevention in early childhood

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Abstract

This paper describes the epidemiologic evidence linking parent-child relationships, self-regulation, and weight status with a focus on early childhood. The emotional quality of parent-child interactions may influence children's risk for obesity through multiple pathways. Prospective studies linking observer ratings of young children's self-regulation, particularly inhibitory control, to future weight status are discussed. Although findings are preliminary, promoting positive relationships between parents/caregivers and young children holds promise as a component of efforts to prevent childhood obesity. Multi-disciplinary collaborations between researchers with training in developmental science and child health should be encouraged.

Keywords

self-regulation; epidemiology; early childhood; obesity; parenting

Introduction

The importance of focusing obesity prevention efforts in early childhood – before children become overweight - is increasingly recognized [1, 2]. Treatment of obesity is challenging [3], and a majority of children who become obese by 8th grade enter kindergarten already overweight [4]. Although the evidence base for obesity prevention in early childhood is growing [5–7], outcomes associated with the available prevention strategies have been modest and may not be sustained [8]. Thus, our understanding of how to prevent obesity in toddlers and preschoolers remains limited [2, 9]. Within this context, researchers are considering approaches to obesity prevention that are broader than diet and physical activity.

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Compliance with Ethics Guidelines
Conflict of Interest
Sarah E. Anderson and Sarah A. Keim declare that they have no conflict of interest.

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Emerging evidence suggests that the emotional quality of relationships between parents and young children impacts risk for obesity [10–17]. Decades of research by developmental scientists demonstrates that positive parent-child relationships support children's development of self-regulation [18, 19]. There is evidence that children who have lower levels of self-regulation have increased risk for obesity [20–26], but this is an emerging area of research [27], and what is meant by "self-regulation" in relation to children's risk for obesity varies across studies.

This paper describes the epidemiologic evidence linking parent-child relationships, self-regulation, and weight status with a focus on early childhood. The biological basis for associations are briefly discussed and future research directions noted.

Evidence linking poor-quality parent-child interaction in young children to risk for obesity

Parenting and its relation to children's weight status is an active area of research [28–32] with growing appreciation of distinctions between parenting styles and parenting practices [33, 34], the bidirectional nature of parent-child interactions [15, 35], and the limitations of relying on parental self-report for assessment [36–38].

High-quality observational methods to assess the quality of interactions between a young child and his/her primary caregiver (often the child's mother) have been developed over many decades and used routinely by developmental scientists to understand children's social, behavioral, and cognitive outcomes [39–41]. Aspects of parental behavior commonly assessed are responsiveness and sensitivity to the child's cues, positive and negative affect, intrusiveness, detachment, cognitive stimulation, and respect for autonomy [39, 42]. The child's affect and behavior, including clarity of cues, as well as the mutuality or synchrony between the child and caregiver can be observed and assessed [39–41]. High quality interactions are marked by the parent's attunement and sensitive and appropriate responses to the child, and mutuality and synchrony within the parent-child dyad. Parent-child relationship quality evolves over time as parents and children alter their behavior in learned response to each other's behaviors and reactions.

Positive parent-child interactions underlie children's attachment security [43–46]. A secure pattern of attachment reflects the child's integrated belief, based on experienced patterns of interaction with their parent/caregiver, that returning to the parent/caregiver when stressed will be a source of comfort [43, 47]. Securely attached toddlers explore and play when they are close to their parent/caregiver, become distressed when separated, but are comforted easily and able to return to play. Insecurely attached children may cling to their parent/caregiver, ignoring the attractions in the environment, protesting strongly or not allowing separation from the parent/caregiver, but not necessarily being comforted by this person's return; alternatively, insecurely attached children may appear precociously self-sufficient, ignoring the parent/caregiver and not seeking them out as a source of comfort or support when scared or stressed [48]. Attachment security has been shown to predict variations in children's, adolescents and adults functioning across multiple domains and contexts [49].

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Physiologic measures of healthy stress response are evident in a secure pattern of attachment [50].

Attachment security and parent-child interactions have been studied prospectively in relation to risk for obesity. The Early Childhood Longitudinal Study, Birth Cohort (ECLS-B) was a large (> 10,000 children) nationally representative sample of US children born in 2001 who were comprehensively assessed through measurements, observations, parent- and caregiver-reports at multiple time points across infancy to kindergarten-entry [51]. The large size, population-based sampling, repeated assessments, and standardized observations of children and parents in their homes made the ECLS-B an excellent study within which to examine associations between attachment security and risk for obesity. Attachment security was assessed in ECLS-B at 24 months of age using the Toddler Attachment Sort [52–54] which was completed by interviewers after they had spent 2–3 hours in the child's home. The children who were in the lowest quartile of attachment security (least likely to be securely attached to their primary caregiver/mother) were more likely to be obese (sex-specific BMI-for-age ≥95th percentile of the US growth reference [55]) at 4.5 years than the children who were more securely attached as toddlers [12]. This association was robust to adjustment for multiple potentially confounding variables including observations of maternal sensitivity/ responsiveness and child behavior [12].

At 9 months of age, the Nursing Child Assessment Teaching Scale (NCATS) was utilized in ECLS-B. This observational measure assesses the quality of interaction between infants and caregivers [40]. There was a trend for lower maternal sensitivity and responsiveness in interaction with their 9-month-old infant to be related to higher risk for obesity at 5.5 years [11]. In contrast, there was no evidence that infant's clarity of cues or engagement with their mother was related to obesity risk. However, although these findings are consistent with the theory that low maternal responsiveness contributes to risk for obesity, the strength of the association was not large and adjustment for sociodemographic characteristics, such as household income and maternal education, attenuated the association such that it was no longer statistically significant [11]. However, there were strong, stepwise relationships between levels of income and maternal education and the likelihood of being in the lowest quartile of maternal responsiveness on the NCATS [11]. Thus, socioeconomic context may be an upstream factor impacting the quality of maternal interaction which would argue that models predicting obesity from some aspects of parenting are over-controlled if adjusted for sociodemographic factors.

Another national cohort, though smaller and not representative of the U.S. population overall, has contributed substantially to understanding contributors to children's well-being. The NICHD Study of Early Childcare and Youth Development (SECCYD) enrolled more than a thousand families from across the US at the birth of their healthy infant in 1991 and assessed them regularly up until age 15 years [39, 56, 57]. Maternal sensitivity and responsiveness in interaction with the cohort child was coded from recorded, semi-structured play-based interactions at 6, 15, 24, 36, and 54 months of age [39, 58]. Researchers, using different analytic approaches, have studied each of these assessments in relation to weight and obesity related outcomes. There is modest correlation between measures of maternal sensitivity and responsiveness across time [39, 58], and high stability of child weight status

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[59]. In 2006, Rhee and colleagues reported that higher maternal sensitivity (above the median in the sample) assessed when children were 54 months old was associated with reduced odds of obesity at age 7 years [17]. Children whose mother displayed low sensitivity and responsiveness (lowest quartile) in interactions at 15, 24, and/or 36 months were at higher risk for obesity assessed in adolescence at a mean age of 15 years [10]. The association was cumulative such that the prevalence of obesity in adolescence was highest when low maternal sensitivity was observed at ≥2 of the 3 time points [10]. Insecure attachment at 24 months was also associated with increased risk for adolescent obesity, but insecure attachment at 15 and 36 months were not [10].

As early as 6 months of age there is evidence that the quality of parent-child interaction is associated with risk for obesity. In an analysis of SECCYD, low maternal sensitivity (below the median) at 6 months predicted higher weight status and risk for obesity in early and middle childhood (through age 12) with some evidence for a combined effect of difficult child temperament and low maternal sensitivity at 6 months with higher school-age weight status [16]. In the Maternal Adversity, Vulnerability, and Neurodevelopment (MAVAN) Study, maternal sensitivity, assessed through coding of approximately 30 minutes of mothers playing with their 6-month-old infant, was associated with higher BMI and overweight/ obesity among girls but not boys at 48 months of age [14]. Maternal sensitivity was modeled as a continuous variable which assumes a linear association between each unit difference in maternal sensitivity and BMI. Low maternal sensitivity was not defined or examined separately [14].

Fewer studies have evaluated the role of observed paternal sensitivity in father-child interaction or children's attachment security with their father relative to children's weight status. The pattern of children's attachment to their mother and father (as well as to other caregivers or siblings) may differ [43]. Evidence regarding the association of paternal sensitivity and child obesity is limited. In a cross-sectional analysis of the 15-year assessment in the SECCYD, maternal and paternal sensitivity were coded from observations of adolescents discussing an area of conflict (e.g., homework, chores) with their mother and, separately, their father [13]. As is consistent with analyses of children in SECCYD when they were younger [10, 16, 17], low maternal sensitivity (lowest quartile) observed during adolescence was associated concurrently with greater prevalence of adolescent obesity, but paternal sensitivity was not associated with adolescent weight status [13]. Using parent self-reports of their parenting behaviors and warmth, a cross-sectional analysis of a large representative study of Australian preschool-aged children found that neither paternal nor maternal warmth was associated with child weight status, but fathers who reported more frequently setting and enforcing limits on their child's behavior had children with a lower prevalence of overweight or obesity [60].

Potential pathways

There are many ways in which poor quality maternal-child interactions could affect children's risk for obesity and understanding potential pathways is an active area of research. Warm-responsive parenting may promote healthy weight in children by influencing how the autonomic nervous system develops. Human brains develop in the context of social

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interaction [61]. The process by which children develop the capacity to regulate their emotions and respond to stress has been studied extensively by developmental scientists [62, 63]. Variation in emotional reactivity in infants can be influenced by caregiving [49]. How caregivers respond to infants and young children may impact the organization of their emerging physiologic responses to stress [61]. The physiologic mechanisms regulating energy balance are complex and intimately interconnected with the autonomic nervous system which is developing rapidly early in life [64]. In response to stress the sympathetic nervous system and hypothalamic-pituitary-adrenal (HPA) axis signal neuroendocrine changes resulting in physiologic arousal and impacting appetite and mood [65, 66]. The synchrony between the brain's signals and body's response may predict whether an individual experiences increased or decreased appetite in response to stress [67]. Adaptation to prolonged or extreme stress may involve habituation and inefficiency in the brain's energy demand signals with the result that increased food intake is required to signal glucose homeostasis [67, 68]. Stress reactivity may be transmitted across generations via epigenetic changes [69].

Another pathway from the quality of parent-child interaction to obesity may be through children's capacity for self-regulation. Self-regulation is a multi-dimensional construct that encompasses the conscious and unconscious [70] neurocognitive processes by which individuals manage and regulate their attention and arousal in order to engage in goal-directed behavior [71, 72]. Self-regulation predicts many positive outcomes for children [73–75]. Self-regulation is modifiable [63, 72], and interventions to improve self-regulation have been developed [76, 77].

Parents' own pattern of attachment, emotional reactivity and self-regulation are factors influencing their parenting behaviors and their interactions with their child. A cross-sectional study of a diverse sample of approximately 500 primary caregivers of 2.5 to 3.5 year-old children (90% were female and 94% were the biological parent of the subject child) recruited from child care centers in Illinois demonstrated associations between caregiver's own attachment style, their pattern of responding to the child's negative emotions, the rules and routines around meals and television viewing they implement, and the child's frequency of eating unhealthful foods (i.e., sugar-sweetened beverages, fast food, sweets, and salty snacks) [78]. Caregivers' insecure attachment representations were associated with poor emotion regulation strategies in response to the child's negative emotions, fewer mealtime routines, more television, greater use of feeding practices thought to promote obesity, and an unhealthier child diet [78]. This study is unique in bringing these associations together and foreshadows the potential for longitudinal studies including direct observation rather than caregiver self-report to move forward our understanding of these complex interrelationships and how they may impact child weight.

Aspects of self-regulation and their assessment in young children

The term 'self-regulation' is used variously by different fields and researchers, and, is sometimes, but not always, distinguished from 'executive function' [71]. Aspects of self-regulation include attention, inhibitory control, emotion regulation, cognitive flexibility and planning. Researchers have recently developed many laboratory-based measures of self-

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regulation for preschool-aged children [79, 80]. It is now clear that the preschool years (ages 3–5) represent a period of significant development of higher-level executive functions. While many 36-month-olds cannot consistently inhibit a simple response to give a different response per instructions, most 6-year-olds can maintain attention and plan out multiple complex steps to solve a puzzle [79]. Table 1 describes some of the most-commonly used assessments for children ages 3 to 6 years.

Development of executive functions in the preschool years has been correlated with school achievement and other long-term outcomes. Young children who can inhibit response appropriately, sustain attention, and plan out their actions have been shown to perform better academically, and once they emerge, executive function abilities appear to be relatively stable over decades [74, 75, 81].

Evidence linking self-regulation in young children to risk for obesity

Despite extensive research on the role of executive function on important cognitive and academic outcomes, there is less evidence for their role in growth and obesity outcomes, particularly in young children [21, 82]. In addition, the facets of executive function that most strongly predict childhood metabolic outcomes remains an active area of research. Inhibitory control has been perhaps the most active area of investigation to date [20, 22, 23, 26, 83], but others domains, such as emotion regulation [24], may also play a role and require further study. Understanding the extent to which children's executive function and general self-regulation relate to appetite and self-regulation in the context of eating will be important and is an active area of research [84–86]. Our focus in this article is on domains of general self-regulation assessed in children who are under 6 years of age using observational/laboratory procedures (i.e., not parent-report) in relation to their weight status or risk for obesity assessed subsequently. Prospective studies are outlined in Table 2 and discussed in the next section.

Analyses of the national Study of Early Childcare and Youth Development indicate that children who, at 3 and 5 years, had more difficulty waiting in laboratory protocols in which they were asked by a researcher to either not touch an attractive toy at 3 years (Gift delay) or to wait 7 minutes to receive a larger portion of a favorite snack food at 5 years (snack delay) were more likely to have high BMI [20] or be overweight [23] at 11–12 years of age.

A series of studies conducted by Graziano, Calkins, Keane and O'Brien [24, 25, 87] provide evidence linking young children's self-regulation to increased risk for obesity. Using a prospective design, with repeated measurement of weight status, they assessed several hundred children from 2 to 10 years of age. At age 2, children participated in laboratory protocols designed to assess their emotional reactivity and ability to regulate emotion, as well as sustained attention (percentage time spent looking at a 5 minute cartoon video) and inhibitory control/delay of gratification (child was presented with an attractively wrapped gift and told not to touch or open it for 2 minutes; time touching the gift was measured). Emotional reactivity and emotion regulation were rated by trained observers based on the child's response to two potentially frustrating situations (holding a clear, but impossible to open, box containing an attractive toy for 2 minutes, and being restrained by a high chair

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without any toys for 5 minutes); the extent to which the child got upset (e.g., fussed, threw a tantrum) measured emotional reactivity and emotion regulation was measured as the extent to which the child used self-soothing or distraction to cope with the situation [24]. Emotional reactivity and emotion regulation were rated separately in each of the two frustration tasks but the measures were highly correlated (r=−0.91) and thus the final analytic variable was the average of the 4 measures. The performance of these 2-year-old children in these domains of self-regulation was related to their body mass index (BMI) and risk for overweight/obesity at 5.5 years [24] and 10 years [25]. Emotion regulation and inhibitory control were more strongly linked to child weight at 5.5 years than was sustained attention [24], but in subsequent analysis these 3 aspects of self-regulation were combined in relation to child weight at age 10 [25]. Of the studies examining children's self-regulation and later weight outcomes, this is the youngest age at which self-regulation was assessed.

These researchers also measured children's heart rate variability/cardiac reactivity at 5.5 years and found that obesity at age 10 was associated with reduced cardiac reactivity for African American but not white youth [87]. Cardiac reactivity, or vagal tone, is a physiological measure of the autonomic nervous system's ability to adapt flexibly and maintain homeostasis across a range of changing and more or less stressful environments. Low cardiac reactivity indicates greater vulnerability to physiologic dysregulation in response to stress. Premature infants have reduced cardiac reactivity [88], and animal studies demonstrate how changes in the quality of care provided in early life can have profound and long-term impacts of the reactivity of an organism in response to stress [69, 89].

The "classic" delay of gratification task for preschool-aged children was developed by Walter Mischel at Stanford University in the 1960s and 1970s [90]. Often referred to as the marshmallow task, it is the basis for the snack delay procedures widely used to assess inhibitory control in young children. The four-year-olds studied at Stanford were recontacted in 2002–2004 as adults (mean age = 39 years) and asked to self-report their current height and weight from which BMI was calculated. A recently published analysis [22] found a linear relationship between the time children were able to wait as preschoolers and their adult BMI; each additional minute of waiting at age 4 was associated with a 0.2 unit lower BMI in adulthood [22]. Although the variance in adult BMI explained by children's self-regulation 30 years earlier when they were preschoolers was not large (< 5%), it was statistically significant with only a modest sample size (n=164) [22]. The finding is meaningful. For example, based on their linear model which adjusted for sex, adult BMI would be predicted to be 2 units higher for a child who waited 12 minutes compared to a child who waited only 2 minutes.

To date, few prospective analyses of young children's general self-regulation in relation to future weight status or risk for overweight or obesity have been published (see Table 2). However, the evidence from this limited base of research is fairly consistent. It is important to note that the analyses published by Francis and Susman [20] and by Seeyave et al [23] are not independent as both utilize data from SECCYD, though with different analytic approaches. A cross-sectional analysis of the MAVAN cohort also suggests that poorer response inhibition at age 4 is associated with higher weight status, particularly in girls [26].

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As the MAVAN cohort is ongoing, results from prospective analyses are likely to be available in the future.

Implications for obesity prevention

Although findings are preliminary, promoting positive relationships between parents/caregivers and young children holds promise as a component of efforts to prevent childhood obesity and bring down the high burden of obesity-related health impacts. Children's brains and the physiology underlying their responses to stress, emotional reactivity, and self-regulatory capacities are developed through repeated interactions with the adults who care for them. Sensitive and response caregiving promotes secure attachment and may also impact metabolic regulation, appetite, and how emotions and appetite are interpreted. Parenting interventions that have been designed to reduce children's risk for behavior problems have shown inadvertent positive benefits for obesity prevention [91]. Interventions to improve parent-child interactions are feasible within pediatric primary care settings and are likely to offer multiple benefits to children and families across domains [101].

Conclusions

This brief review highlights emerging research on interrelationships between the emotional quality of interactions between parents and young children, self-regulation, and obesity. Many aspects of self-regulation can be assessed in preschool-aged children. Inhibitory control has been most often studied in the context of childhood obesity. Additional research is needed to confirm and extend the evidence base. Multi-disciplinary collaborations between researchers with differing perspectives on children's growth and development within families is likely to suggest new approaches to childhood obesity prevention [27].

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Table 1

Commonly used assessments of aspects of self-regulation in preschool-aged children

Measure	Primary Executive Function Demand(s) Evaluated	Format	Reference
Snack delay	Inhibitory control	Task	Kochanska 2000 [73]
Gift delay	Inhibitory control	Task	Kochanska 2000 [73]
Count and Label	Working memory	Task	Gordon & Olson 1998 [92]
Day/Night, Grass/Snow	Inhibitory control, working memory	Task	Gerstadt 1994 [93]; Carlson & Moses 2001 [94]
Disappointing gift	Emotion regulation	Task	Saarni 1984 [95]
Standard Dimensional Change Card Sort	Working memory	Task	Zelazo 2003 [96]
Tower of Hanoi	Planning	Task	Welsh 1991 [97]
Shape School	Switching, inhibitory control	Task	Espy 1997 [98]
BRIEF-P	Multi-dimensional	Parent or teacher report	Gioia 2000 [99]
Continuous Performance Test (CPT)	Attention, Inhibitory Control	Computerized test	Mahone 2001 [100]

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Table 2

Assessment and definition of self-regulation in studies linking self-regulation in young children (<6 years) to future obesity risk

Reference	Aspect (s) of self-regulation assessed	Assessment/method	Scoring	Analysis variable/findings
Francis, 2009 [20]	Inhibitory control	"Waiting game" Child (age 36m) asked to refrain from touching an attractive toy while researcher out of the room for 150 sec.	Time child waited before touching the toy. Dichotomized as <75, ≥75 sec.	Four mutually exclusive groups of children were defined based on the combination of performance to the age 3 and age 5 tasks: low at both ages; high at both ages; low at age 3; low at age 5. BMI z-score for children who were low at both ages was higher across childhood (age 3 to age 12 years).
	Inhibitory control/delay of gratification	"Snack delay" Child (age 54m) told he/she could have small number of a favorite food right away or wait 7 min for the researcher to return and get a larger number.	Time child waited before eating/touching the snack. Dichotomized as <210, ≥210 sec.	
Seeyave, 2009 [23]	Inhibitory control/delay of gratification	"Snack delay" Child (age 54m) told he/she could have small number of a favorite food right away or wait 7 min for the researcher to return and get a larger number.	Whether the child waited the full 7 min for the researcher to return or not (binary variable).	Children who did not wait the full 7 minutes had odds of overweight at age 11 years that were approximately 1.3 times those of children who did wait.
Graziano, 2010 [24] and 2013 [25]	Frustration tolerance/reactivity and emotion regulation	"Prize in the box" and "High chair" In two separate tasks, Child (age 24m) given a clear box containing a toy that they were unable to access for 2 min; child put in a high chair without toys for 5 min.	Child's negative emotion (fussing, crying, etc) was rated from 0 (none) to 4 (extreme distress). The extent to which the child regulated their distress by self-soothing, distraction etc was also rated on a 0 to 4 scale.	Measures of reactivity and emotion regulation were highly correlated and combined in analyses. Children who displayed less frustration and were more able to regulate their emotions, and children who spent less time touching the gift had lower BMI z-scores at 5.5 years. Sustained attention was less strongly related to child weight at 5.5 years. All 3 measures of self-regulation at age 2 were combined and better self-regulation was associated with lower weight status when children were 10 years old.
	Sustained attention	Child (age 24m) shown a 5-min cartoon video.	Proportion of time that child was watching the video measured.	
	Inhibitory control/delay of gratification	"Gift delay" Child (age 24m) presented with an attractively wrapped gift and told he/she could not touch it for 2 min.	Proportion of time the child was touching the gift (reverse scored).	
Schlam, 2013 [22]	Inhibitory control/delay of gratification	"Snack delay" Child (age 4 years) told they could have a larger reward (2 vs 1 cookies, marshmallows, or pretzels) if they waited for the experimenter to return (~15 min) or they could ring a bell to bring back the experimenter and they could have the smaller reward (i.e., one marshmallow, etc).	The number of minutes the child waited was measured (top coded at 15 minutes).	Greater ability to delay gratification at age 4 was associated with self-reported BMI when participants were recontacted as adults at a mean age of 39 years. Each additional minute waited predicted a 0.2 unit lower BMI in adulthood.